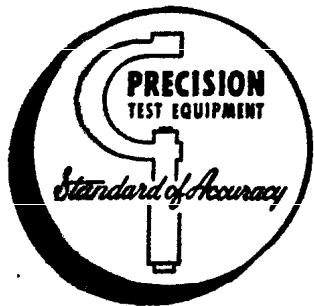
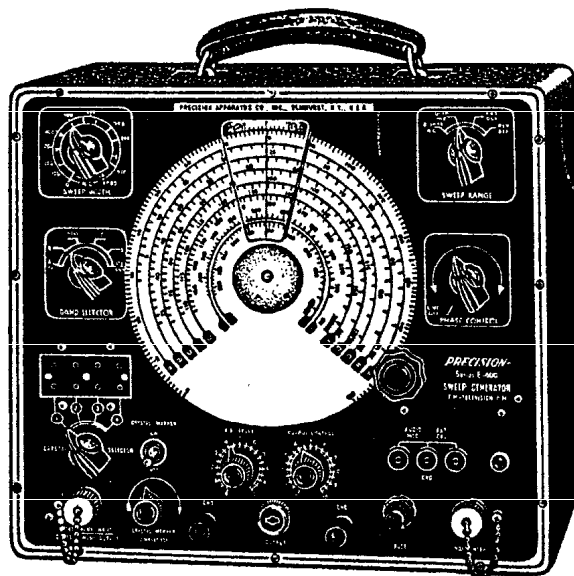




OPERATING INSTRUCTIONS for *-PRECISION-*

SERIES



E-400

SWEEP SIGNAL GENERATOR

PRECISION APPARATUS COMPANY, INC.

92-27 HORACE HARDING BLVD. • ELMHURST, L. I., N. Y.

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* * * *

Prepared by

THE ENGINEERING DEPARTMENT

PRECISION APPARATUS COMPANY, INC.,
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SERIES E-400

GENERAL SPECIFICATIONS

The PRECISION Series E-400 Sweep Signal Generator is a wide range multi-purpose frequency modulated Signal Source specifically designed for alignment and service of television, F.M. and other high frequency type receivers and circuits.

All phases of its design have been particularly coordinated by Precision engineers with the latest advances in Television receiver developments:- all special functions and check-circuits within the Generator therefore provide utmost flexibility of application, rendering the E-400 unusually adaptable to future revisions in TV and other receiver design and frequency specifications.

For example:- required flexibility of Marker injection frequencies has been accomplished by use of an internal multi-channel Crystal-Marker Oscillator PLUS rapid-injection external Variable Marker Oscillator facilities. This completely eliminates the need for a costly yet limited range internal Variable Marker Oscillator, which would be readily subject to early obsolescence.

Intelligent, coordinated use of the Series E-400 Sweep Generator will reveal to the operator its unusual diversity and flexibility of operation, in keeping with the established PRECISION reputation for "The Finest in Test Equipment".

1. Continuous Frequency Coverage: 2 megacycles to 240 megacycles Direct Reading in five bands without skip. Dial is calibrated to 480 megacycles.
2. 6 $\frac{1}{2}$ " No-glare, Aluminum Tuning Dial: Engine-turned finish with approximately 5 $\frac{1}{2}$ feet of easy reading, 2 color, deeply etched scales. High ratio, zero back-lash, rear rim drive.
3. 1500 Point Vernier Reference Scale and engraved Lucite Hair-line indicator. Direct reading to one part in 1500 for critical applications and odd frequency spotting. Lucite transparent indicator affords direct frequency readings free from parallax.
4. Calibration Stability: By use of specially selected and designed ultra-high frequency components, circuits, and construction details, plus full voltage-regulated oscillator power supplies, utmost practical frequency stability and accuracy is assured. On all bands, each contributing oscillator frequency is within $\pm 1\%$. (See page 25)
5. Variable-Frequency Deviation Control: Direct reading, narrow and wide band. Sweep Frequency band widths of 0-1 MC and 0-15 MC continuous, for all FM and TV requirements.
6. Blanking Circuit: Eliminates dual trace of response pattern on oscillograph and provides a zero reference line which is especially useful for adjusting wave-traps and aligning discriminators.
7. The Circuit: 6J6 reactance modulated oscillator; 6C4 low frequency fixed oscillator; 6C4 high frequency fixed oscillator; 6J6 electronic frequency mixer; 6J6 R.F. Amplifier and marker-mixer amplifier; 6C4 multi-frequency crystal marker oscillator; VR-105 voltage regulators; 6X5 full wave rectifier.
8. Phasing Control and Horizontal Sweep Output supply provided directly at front of panel.
9. Built-in Crystal Marker-Calibrator-Oscillator with a PRECISION designed multi-crystal socket, at front panel: provides for simultaneous insertion of ANY four crystals for applications requiring use of crystal-accuracy marker and calibrating pips. Eliminates the inconvenience of frequent insertion and removal of crystals. Each of the 4 crystal positions quickly selected by rotary switch. Crystal Marker amplitude separately controlled.
10. Variable Frequency Marker Input terminal provides direct means for use of any standard, adequate AM signal generator as marker pip-generator. Series E-400 does not duplicate VFO (Variable Frequency Oscillator) facilities already existent in every service laboratory.
11. Dual RF Attenuation System: 2 continuous (stepless) variable attenuators afford smooth control of E-400 output. Double copper-plate shielded.
12. Terminated low-loss Co-axial R.F. Output Cable (RG-62/U): Affords non-reactive injection of test signals. "High-low" plus open line terminal impedance for utmost flexibility of application.
13. External Deviation input terminals afford direct facility for sweep operation at other than built-in supply frequency.
14. External Amplitude Modulation input terminals afford direct means for Amplitude Modulation of complete E-400 R.F. range with or without the presence of the F.M. Both features 13 and 14 are particularly valuable adjuncts to the more serious minded service technician, and electronic manufacturer.

15. Extractor Fuse Post at rear of instrument affords simple fuse replacement when and if necessary.
16. Elaborate dual Copper-plate and aluminum shielding of all R.F. generating sections.
17. Separate Line Filter, in separately shielded compartment assures minimum radiation from line cord.
18. Etched and Anodized heavy gauge aluminum panel resistant to effects of moisture and abrasion.
19. Fully licensed under patents of Western Electric and Remco Electronic, Inc.
20. Telephone type cabled wiring using highest quality plastic insulation.

* * * I. INTRODUCTION * * *

The technique of Frequency Modulation and Television servicing, while basically related to A.M. alignment and service, involves a number of relatively new concepts and procedures which differ radically from the standard A.M. techniques.

Before attempting to proceed with F.M. and T.V. alignment and servicing, the serious technician must become well-schooled in both the theory and in the practical aspects of F.M. and T.V. The satisfactory solution of problems such as determination of I.F. bandwidth, balanced alignment of F.M. discriminators, adjustment of limiter stages, etc. in F.M. receiver alignment; and the adjustment of trap circuits, alignment of Video I.F.'s, R.F. and oscillator circuits in Television receivers etc., all require not only receiver circuit familiarity, but an understanding of the application of Sweep Generators, Oscillographs and associated visual alignment equipment.

All this knowledge is not as difficult to obtain as would appear from a cursory discussion; however it is imperative that the F.M. and T.V. service technician prepare himself for intelligent efficient servicing by the study of informative literature such as Riders Television Manual, "Kiver's Television Simplified" and "F.M. Simplified", and/or other similar practical and theoretical works including various trade journals such as Radio Maintenance, Radio Service Dealer, Service, etc.

This instruction manual is primarily intended to acquaint the technician with the operation and application of the PRECISION Series E-400 Sweep Generator and its application to F.M. and T.V. servicing. No attempt will be made to discuss, in great detail, the theoretical and functional aspects of F.M. and T.V. receiver operation. The contents of this instruction book can be properly assimilated ONLY if the technician has ALREADY familiarized himself with T.V. and F.M. Receiver operational aspects.

* * * II. PRINCIPLES OF OPERATION OF THE SERIES E-400 SWEEP GENERATOR * * *

The primary function of a Sweep Generator is to provide the means for obtaining on the screen of a cathode ray oscillograph, a PICTURE of a circuit response curve. The standard A.M. method of PEAKING a tuned stage (such as an I.F. stage) by means of an A.M. signal generator and V.T.V.M. may not be adequate in the case of F.M. and is quite inadequate with T.V. due to the fact that the response of the tuned stage must be adjusted NOT ONLY AT THE MID-POINT of the response curve but at other points ALONG the response curve. The only rapid and convenient means of adjusting the OVERALL shape of a very broad response curve is to OBSERVE THE PICTURE of the wave-shape on an oscillograph screen and simultaneously adjust the response of the tuned circuits involved.

In order that the technician be fully aware of exactly HOW a response curve is obtained on an oscillograph and what the response curve represents, the following explanatory discussion is set forth:

1. Reference to Fig. 25B (page 31) indicates the normal operation of the usual type cathode ray oscillograph before external potentials are applied to the VERTICAL amplifier of the oscillograph:
The internal horizontal sweep system of the oscillograph is sweeping the electron beam back and forth horizontally (at a rate determined by the Horizontal Frequency Control of the oscillograph) creating the picture of a straight horizontal line.
2. As the output of the E-400 is applied to a 10.7 megacycle F.M. I.F. system, (for example) an R.F. signal, varying or "sweeping" from 10.775 MC. to 10.625 MC. 60 times per second, is transmitted through the I.F. system.

The latter point is an important one for the technician to remember, because it relates directly to the fact that all voltages from F.M. stages, Video second detector stages etc. which will be connected to the Vertical terminals of the oscillograph in the usual F.M. and TV servicing procedure (using a Sweep Generator), will be low in frequency, and therefore the use of the standard type of cathode ray oscillograph with high vertical sensitivity is all that is actually required. So called wide band 'scopes are not necessary for F.M. or TV alignment. A wide band 'scope is a very specialized, costly device having limited general utility.

Now, to return to our original thought the exemplary I.F. system has a frequency response characteristic itself which may appear as noted in Fig. 25A. The shape of this characteristic indicates that a signal at (for example) exactly 10.70 MC will be passed at maximum amplitude (point "X", Fig. 25A). A signal of 10.75 MC will be attenuated somewhat, while a signal at 10.8 MC will be practically completely attenuated, etc. Therefore the total bandwidth of the I.F. response curve is "swept" through by an applied R.F. signal whose frequency is being shifted. The I.F. system will pass this signal at magnitudes proportional to the shape of its response curve.

This I.F. signal (high frequency A.C., varying in amplitude 60 times per second by virtue of the 60 cycle sweep rate of the E-400) is usually applied to a Limiter stage in an F.M. receiver (or to the Video detector stage in a TV Receiver).

In order to actuate the Vertical amplifiers of the oscillograph, this range of I.F. frequencies (whose amplitudes are varying 60 times per second in accordance with the I.F. response curve) must be rectified. In a video detector, such rectification takes place across the Video detector load resistor.

(In an F.M. receiver, the oscillograph is connected across the limiter grid leak resistor (points "W" and "GND" Fig. 4, page 9). This point provides a varying low frequency voltage due to the fact that the magnitude of voltage developed across the limiter or detector load resistors "follows" the amplitude of the signal impressed upon their circuits.

This "response voltage" (which is varying in amplitude 60 times per second), causes the beam of the oscillograph cathode ray tube to travel up and down 60 times per second. Without any Horizontal deflection of the beam, the picture on the screen of the oscillograph would be a vertical straight line. If, however, a voltage varying 60 times per second (as is provided by the E-400) is applied to the Horizontal deflecting system of the oscillograph, the beam would then be horizontally deflected at the same rate it is being vertically deflected. This results in a spread-out pattern, reproducing the response characteristics of the receiver I.F. amplifier system.

* * * * *

Fig. 23, page 30, illustrates, in block fashion, the circuits within the Series E-400 which produces the frequency modulated or "Swept" R.F. signal which is to be injected into the receiver tuned circuits.

OSCILLATOR "A", the variable Frequency-Modulated oscillator, covers a fundamental range of 71 to 120 MC. At every point within this frequency range, the oscillator is frequency modulated by a specially designed electro-mechanical reactance modulator unit. This unit varies the inductance and capacity of the oscillator tuned circuit thru the medium of a sinusoidally actuated aluminum deviator. The oscillator frequency is thereby varied above and below the oscillator mean frequency at a 60 cycle repetition rate. With the blanking switch on, the oscillator is cut off for 180° of each F.M. cycle producing a zero reference line on the 'scope.

The output of oscillator "A" is therefore a frequency Modulated R.F. signal, whose mean frequency is manually tunable between 71 and 120 megacycle.

OSCILLATOR "B" and "C" are fixed frequency oscillators calibrated at 75.0 MC and 37.5 MC respectively. In operation of the Series E-400 only one of these oscillators is in use at any one time. The use of two fixed frequency oscillators provides greater flexibility and wider frequency range, without skip.

The output of Oscillator "A" and either one of Oscillators "B" or "C" are simultaneously injected into a high frequency R.F. mixer stage labeled "D". This stage, as its name implies, mixes the R.F. signals of oscillator "A" with "B" or "C" and delivers the carriers, sums, and difference frequencies to the "R.F. Amplifier-Marker Injection" stage (labeled "E").

The advantage of using the beat frequency system thus far described becomes evident upon examining the wide frequency range versus sweep frequency requirements of an F.M.-T.V. Sweep Generator (2-240-480 MC.). If the output of the individual oscillators were used, the multiplicity of oscillators, the intricate band switching and the complex construction and stability problems involved in the relatively high frequency oscillators which would be required would render the cost of such an instrument excessively high, and the operation prohibitively complicated and unwieldy. Therefore by the relatively simple expedient of using additive and subtractive beats of only 3 oscillators, the objective of wide frequency range is accomplished in a simple fashion. Furthermore, since Oscillator "A" is the only section subjected to reactance modulation, the sweep problem is directly and most efficiently handled independent of oscillators "B" and "C".

A requisite in aligning the tuned circuits of F.M. and TV receivers is the accurate determination of center frequency of tuned circuits and also of the frequency of selected points along the tuned circuit response curve. For example:- the center frequency point of the overall I.F.'s of an F.M. receiver may be 10.7 megacycles. However the band width of the overall response curve may be specified by the receiver manufacturer to be 75 KC on each side of the center frequency of 10.7 Mc. (150 KC overall). A typical response curve of this type is illustrated in Fig. 26A, Page 33. In order to align the overall I.F.'s in accordance with such requirements, facilities must be provided which will permit visual marking of the 10.7 MC point and (for this example) the 10.7 MC plus 75 KC., and 10.7 MC minus 75 KC points.

In the E-400 this objective is accomplished by a choice of two methods.

The first method incorporates the use of the internal Crystal Marker Oscillator "F" (Fig. 23). This oscillator, when used in conjunction with the proper crystal, injects an R.F. Signal at the desired Marker frequency (for example 10.7 MC.) into the Marker injection stage E and superimposes a Marker or Pip at the 10.7 MC. point on the response curve itself. (See Fig. 26G) page 32. Side pips or Markers at both the 10.7 MC. plus 75 KC., and 10.7 MC. minus 75 KC. (10.775 MC. and 10.625 MC.) will then reveal, visually, the alignment and bandwidth of the tuned circuit.

The second method permits the technician to use his regular A.M. Signal Generator, such as PRECISION Series E-200C, as a variable frequency Marker Generator (noted as "G" on the block diagram) either in conjunction with the internal crystal calibrator, or as an external Marker Generator independent of the internal crystal calibrator. Both of the above methods will be treated in greater detail further on in this manual.

The output of the internal crystal calibrator alone is available from the front panel connector for use as an accurate crystal controlled R.F. signal, as a trap generator, and for other applications wherein a fixed unmodulated R.F. signal is required such as for calibration of R.F. sources, etc.

The output of the R.F. amplifier "E" is fed to a terminated transmission line thru a shielded, continuously variable dual attenuator system.

* * * III. FUNCTIONS AND DESCRIPTION OF SERIES E-400 PANEL CONTROLS AND SWITCHES. * * *

1. Main Tuning Dial, and Band Selector Switch

a. The Markings "A(X)", "B", "C(Y)", "D", and "E" on the "BAND SELECTOR" switch refer to the corresponding Bands on the main tuning dial.

b. The Marking "A(X)", "C(Y)" indicate that Bands "A" and "X" are in operation when the band selector is set to "A(X)" and that Bands "C" and "Y" are in operation when the "BAND SELECTOR" is set to "C(Y)".

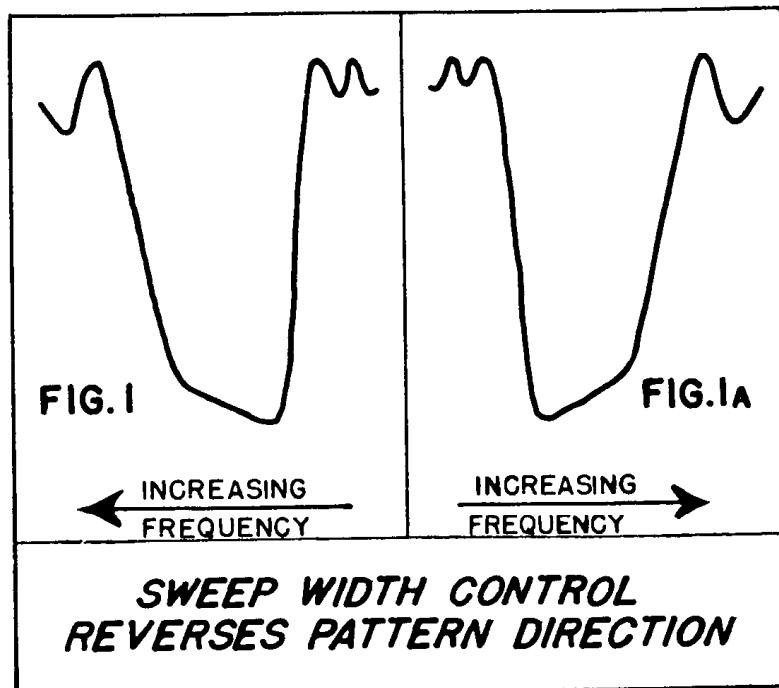
c. When the "BAND SELECTOR" switch is rotated to the position marked "XTAL only" all oscillators with the exception of the internal CRYSTAL MARKER oscillator are disabled, permitting application of just the pure CRYSTAL MARKER oscillator output as a simple crystal oscillator for external use with no interference from the remainder of the generator's oscillators.

2. Sweep Width Control

Manipulation of the "SWEEP WIDTH" control varies the degree to which the variable oscillator (OSC. "A") is deviated from its mean frequency. This control also permits the operator to REVERSE the horizontal direction of response curves. See Fig. 1. Rotation of the control from "0" to a clockwise position will reverse the curve as in Fig. 1A.

The calibrations of the "SWEEP WIDTH" control are NOT intended for use as accurate indications of Sweep Width. They ARE for use as a CONVENIENT GUIDE to the APPROXIMATE setting required to bring the full response pattern into view on the 'scope screen.

NOTE: Double Sweep Width (up to 30 MC. Deviation) can be obtained, if desired, on Band "E" by using Band E on the main tuning dial and setting the "Band Selector"



3. Sweep Range Switch

This switch sets the range for which the "SWEEP WIDTH" Control is calibrated, (0-1000 KC. or 0-15 MC.). The third position (marked "EXT DEV.") frees the reactance modulator from its internal 60 C.P.S. excitation and allows the operator to excite the reactance modulator from an external A.C. source thru use of the panel pin jacks marked "EXT. DEV.". The fourth position (marked "DEV. OFF.") disables the reactance modulator from both internal and external deviation sources.

4. Phase Control

Due to the fact that full sinusoidal voltages are simultaneously applied to the Reactance Modulator and the "HOR. SWEEP" terminals of the oscillograph, two traces of the tuned circuit response curve will normally appear on the oscillograph. Without corrective networks, one of

the traces will usually be found out of phase with the other trace, resulting in both traces appearing on the oscillograph, adjacent to each other. The "PHASE CONTROL" operates a capacity phase-shift network which permits both traces to be superimposed on the oscillograph.

5. Blanking Switch

By means of the blanking switch one of the traces can be eliminated and a zero base line produced on the 'scope. When the blanking switch is in the "ON" position a specially shaped voltage pulse is applied to the grid of the variable oscillator tube. This negative voltage pulse is of sufficient amplitude to disable the variable oscillator for 180 degrees of each modulating cycle. By means of a special network the blanking voltage is correctly phased with respect to the motion of the electro-mechanical reactance modulator unit. During the time the variable oscillator is cut off there is no output from the circuit under test, consequently the beam of the cathode ray tube in the oscillograph is not deflected vertically and a zero reference line is produced. This zero reference line is especially useful for estimating the attenuation of wave-traps and for obtaining symmetrical discriminator response curves.

6. Output Controls ("RF LEVEL" and "OUTPUT CONTROL")

The control labeled "RF LEVEL" adjusts or controls the magnitude of R.F. which is fed or transmitted to the "OUTPUT CONTROL". With the "OUTPUT CONTROL" set to maximum, the "RF LEVEL" control should be set at a point which will result in the maximum output required for the particular application. From that point on the "OUTPUT CONTROL" should be used to attenuate the signal from the Sweep Generator.

7. Crystal Marker (Selector, Attenuator and Panel Connector and Switch).

A. Crystal Selector Switch. When one to four appropriate crystals are inserted into the multiple crystal socket this switch will select any one of the 4 crystals and electrically insert them into the internal crystal oscillator circuit.

B. Crystal Marker "ON-OFF" Toggle Switch: This switch permits the internal crystal marker oscillator to be turned ON or OFF. In use it may be noted that simultaneously with the appearance of a "pip" caused by the Crystal Marker, other "pips" may also appear at other points on the response curve. These additional "pips" are normal occurrences and are caused in many cases by the presence of other R.F. signals in the receiver and related extraneous beats. If the "ON-OFF" toggle switch is thrown "ON" and "OFF", the "pip" caused by the Crystal Marker will appear and disappear providing thereby positive identification of the Crystal Marker "pip". When the internal Crystal Marker is not required, this toggle switch should ALWAYS be thrown to the "OFF" position.

C. Marker Amplitude Control. The "CRYSTAL MARKER AMPLITUDE" control is an attenuator for the internal crystal marker oscillator. In use, the amplitude or height of the marker "pip" will increase as the Control is turned clockwise. This control should be advanced only as far as required to just produce a visible "pip" or "marker". If the control is advanced to obtain an excessively strong "pip", the overall response curve may be distorted by the strong marker signal.

D. "EXT. MARK. INPUT - CRYSTAL MARK. OUTPUT" CONNECTOR. This connector permits the operator to obtain externally (in conjunction with the "Marker Cable" and "Cable Adapter"), the output of the Crystal Marker oscillator only, for a variety of purposes. As noted previously for this function the "BAND SELECTOR SWITCH" must be rotated to the "XTAL ONLY" position.

This same connector, used in conjunction with the Marker Cable, allows the operator to inject an external marker signal into the E-400.

8. "HOR.-SWEEP" CONNECTOR

This connector, when used in conjunction with the H-SWEEP CABLE, supplies Horizontal sweep actuating voltage to the "Horizontal" or "H" terminals of the oscillograph being used.

NOTE: In the case of the PRECISION ES-500 Cathode Ray Oscillograph, the "Range" switch of the Oscillograph must be rotated to the "EXT. SW." (External Sweep) position. On other oscillographs, the appropriate switch must be set to similar position in order to allow the "H-Sweep" output of the E-400 to actuate the Horizontal amplifiers of the oscillograph.

If the operator so chooses, he may, in certain applications, dispense with the use of the "HOR. SWEEP" output of the E-400 set the "Range" switch of the oscillograph to approximately 60 cycles per second thereby using the internal sweep of the oscillograph for horizontal deflection. (See Page 8, 5B).

9. "EXT. DEV." PIN JACKS (External Deviation)

With the "Sweep Range" selector switch rotated to the "EXT. DEV." position, an external source of AC voltage at a frequency between 25 to approximately 200 C.P.S. may be applied to the "EXT. DEV." pin jacks, thereby externally exciting the reactance modulator.

IMPORTANT NOTE: Care must be exercised when applying external A.C. voltage to the "EXT. DEV." pin jacks: Should excessive voltage be applied, the reactance modulator driving coil may be overloaded and damaged. Apply only enough voltage as will yield sufficient sweep width to bring the entire response curve of the tuned circuit under test into view on the oscillograph screen. (Approx. 1.5 volts maximum).

When an external source of sweep potential is employed, the approximate deviation calibrations of the "SWEEP WIDTH" control is no longer applicable.

10. "OUTPUT" CONNECTOR

The Output Cable (with termination box) connects to the "Output" connector on the instrument panel.

11. BINDING POSTS ON PANEL

These binding Posts are provided for additional grounding connections to be made by the operator. One grounding strap (supplied with the E-400) should be connected from one binding post on the E-400 Panel to the receiver under test. If found necessary, another ground connection may be made by the operator from the other binding post to another point on the receiver or to the oscillograph being used.

* * * IV. PRELIMINARY SET-UP PROCEDURE * * *

Fig. 2 illustrates the interconnection set up between the required Test Instruments and the receiver to be aligned.

1. The OUTPUT CABLE (with termination box) connects between the "OUTPUT" connector on the E-400 panel and the input of circuit under test.
2. The output of circuit under test connects, by means of an isolating resistor and a 2 conductor cable (preferably shielded), to the "V" or Vertical input posts of the oscillograph. (See page 7).
3. The "H" SWEEP cable connects between the "HOR. SWEEP" connector on the E-400 Panel and the "H" or Horizontal input posts of the oscillograph.
4. The use of a Variable frequency marker or "pip" generator in addition or supplementary to the fixed crystal marker is strongly recommended. A standard AM Generator typified by PRECISION Series E-200C is ideally suited for this purpose and may be interconnected in any one of several fashions to produce the desired "pip" or Marker. Suggested methods of Variable marker injection are noted as follows:

A. Connect the double-ended "Marker Cable" (supplied with the E-400) between the "High Output" connector of the E-200C and the "EXT. MARKER INPUT" connector of the E-400. If unusually strong markers are desired when using the test connections described on the previous page, the operator may use an unshielded wire to connect the E-200C to the E-400. For this purpose, attach standard female microphone connectors at each end of a suitable length of stranded insulated wire, and use this unshielded lead in place of the double-ended "Marker Cable" (supplied with the E-400). See Fig. 17. In general, however, the markers obtained by use of the shielded cable are entirely adequate,

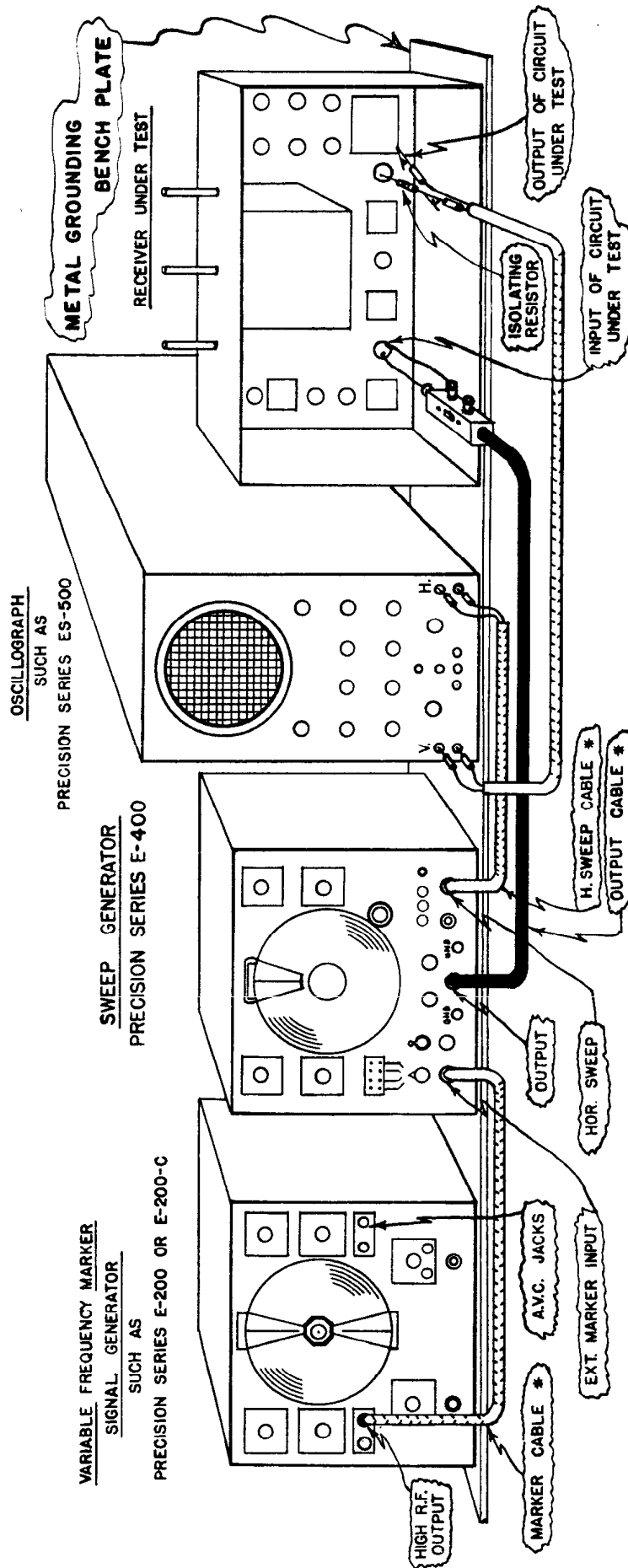
OR

B. Use the output cable supplied with E-200C itself (terminates in alligator clips) and CONNECT BOTH ALLIGATOR CLIPS TO THE TV SET CHASSIS AS CLOSE AS POSSIBLE TO THE POINT WHEREIN THE OUTPUT OF THE E-400 IS BEING INJECTED INTO THE SET (space the alligator clips approximately 6 inches apart). This "chassis" method of injection introduces circulating R.F. currents in the set chassis and is quite effective in the injection of strong marker pips, while minimizing distortion and loading effects. (See Fig. 2A)

OR

C. Occasionally it may be found desirable to connect the output of the E-200C directly in parallel with the "High" and "GND" posts of the E-400 output termination box. This direct method of marker injection while capable of injecting strong marker signals, almost invariably produces a degree of response curve distortion and is considered the least desirable of the three methods outlined.

TYPICAL SETUP FOR VISUAL ALIGNMENT WITH "PRECISION" SERIES E-400 SWEEP GENERATOR



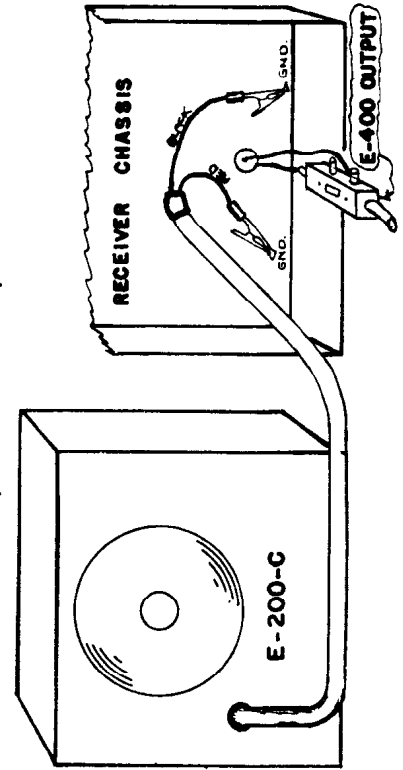
* - SUPPLIED WITH E-400

FIG. 2

FIG. 2A

ALTERNATIVE METHOD OF MARKER INJECTION ("CHASSIS" METHOD)

1. The "GND" post on the E-400 output cable Termination Box has been designed to allow the termination box to be conveniently suspended from a point on the chassis above the "hot" injection point. This method of "hanging" the termination box facilitates short connections to the receiver.
2. Whenever a pattern of unstable or highly questionable shape appears on the oscillograph screen, always check grounding connections between the instruments. Secure grounding connections between test instruments and receiver are required at all times.
3. Marker signals should always be held at a minimum amplitude consistent with visibility in order to minimize distortion of the response curve shape.



5. The Controls, switches etc. of the Test instruments should be initially set as follows:

(A) E-400

1. "PHASE CONTROL" advanced approximately half rotation.
2. "BAND SELECTOR" switch set to proper frequency band.
3. "SWEEP RANGE" switch set to proper range (0-1000 KC. for F.M.; and 0-15 MC. for TV).
4. "CRYSTAL SELECTOR" switch set to proper position (if internal crystal marker is to be used) and "CRYSTAL SELECTOR" ON-OFF switch thrown to "OFF" position.
5. "R.F. LEVEL" control advanced to full rotation.
6. Blanking off.

(B) Oscilloscope

1. Normal set up, in accordance with oscilloscope instruction manual, with the following exception:
 - a) "SWEEP SELECTOR" (of PRECISION Series ES-500 or ES-500A, or "RANGE SWITCH" of other oscilloscopes) set to "EXT. SW." (or equivalent setting on other oscilloscopes which allows for use of external sweep voltages.)

IMPORTANT NOTE: In view of field experience, it appears desirable to strongly emphasize the desirability of using the "EXT. SW." (or equivalent position of the sweep-selector switch). In general, the use of sawtooth sweep is not recommended for alignment applications, because the display may be somewhat difficult to control under these conditions of alignment.

(C) Variable Frequency Marker Generator (such as PRECISION Series E-200 and E-200C)

1. Normal Set-up, in accordance with the E-200 and E-200C Instruction book, for obtaining an unmodulated R.F. signal of required frequency.

* * * V. BASIC ALIGNMENT PROCEDURES * * *

1. F.M. Receivers

NOTE 1: In the following alignment procedures, illustrations of typical response curves will be noted. The operator should bear in mind that these response curve illustrations are presented as generally typical of the type curves which may be expected. The response patterns which will be obtained, using any one particular F.M. or television receiver, may vary and differ in shape from the illustrations presented herein. The operator should always refer to curve illustrations of the set manufacturer in his instructions for the particular set under alignment.

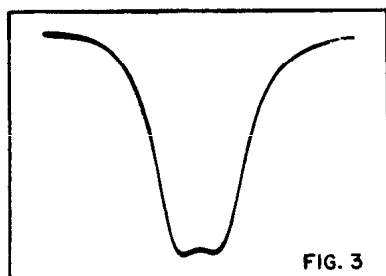
NOTE 2: The "GND" connection on the termination box of the E-400 output cable should always be connected or clipped to a spot on the receiver chassis nearest to the circuit whereat the test signal is to be injected.

NOTE 3: In the following procedures, only the usual limiter-discriminator type of F.M. receiver will be discussed. Procedures for alignment of Ratio Detector type, Locked-In Oscillator, gated beam type and others, utilize the same basic alignment technique and need not be covered herein. Manufacturers of/or Service Manual Instructions fully cover these latter techniques.

The four basic alignment steps required in F.M. receiver tuning are listed as follows:

- A. I.F. Alignment
- B. Discriminator Alignment.
- C. Oscillator Alignment.
- D. Overall check of R.F. and I.F. stages.

(A) I.F. Alignment



The overall response curve of a typical F.M. -I.F. system is indicated in Fig. 3. However, the operator should always refer to the Manufacturers' detailed instructions and be guided by the information and specific curve illustrations therein. (For the purposes of this instruction book, a typical I.F. response curve (10.7 MC resonance point; 150 KC total width along the "flat top" portion of the curve (75 KC either side of center) will be discussed).

The overall response curve of the typical I.F. system may be produced within the receiver by a stagger-tuned system or by individual 10.7 MC. "double-humped" (over coupled) stages. In both cases alignment is effected by "progressive" adjustment (similar to the standard A.M. method). This is performed by injecting the signal from the E-400 into the grid of the I.F. tube nearest the limiter or discriminator and by individually aligning each stage as the E-400 output is progressively connected to each I.F. grid, working back to the converter grid.

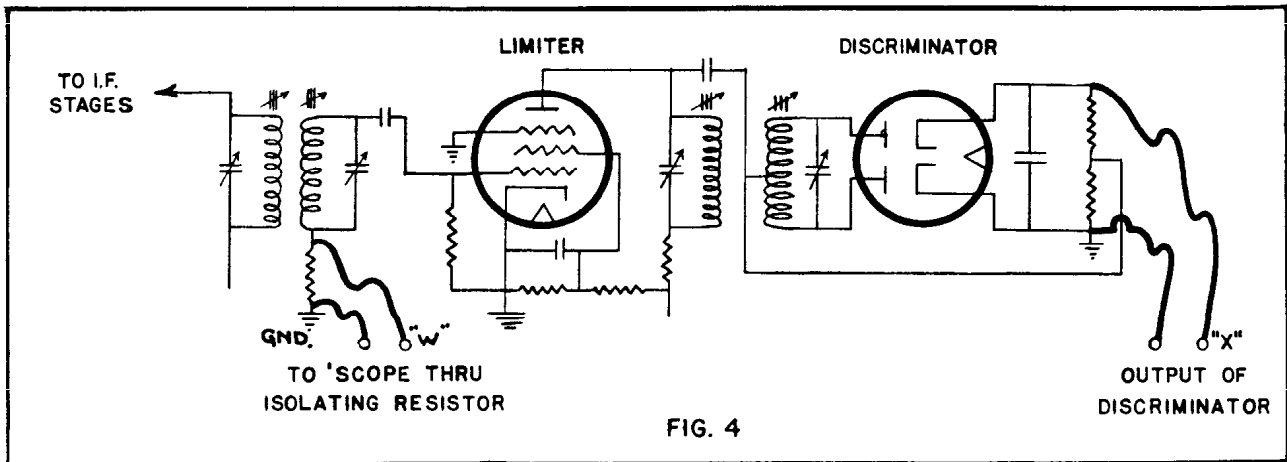


FIG. 4

A typical application is detailed as follows:

The E-400, oscillograph (and external variable marker, if used) is set up in accordance with Fig. 2. The output cable termination box of the E-400 output cable is switched to the "Termination Switch" "IN" and the "High" terminal is used. The termination switch may be thrown to "OUT" if more output is required; however, if a slightly different wave shape (not a difference in overall amplitude) is obtained when the Termination Switch is thrown to "OUT", the switch should be returned to "IN".

For alignment of the I.F. stage nearest the limiter or discriminator, the "High" terminal of the E-400 output cable is connected to the grid of the I.F. tube. The "GND" terminal is connected to the receiver chassis.

The "V" terminals of the oscillograph are connected to points marked "W" and "GND." on Fig. 4.

NOTE: The "hot" "V" lead should not be connected directly to this point "W". A 25,000 to 250,000 ohm, 1/2 watt carbon resistor must be connected in series with the "hot" lead and point "W". This resistor acts as an isolating element minimizing loading effects which could result in distortion of the oscillograph pattern; it also sharpens up the marker greatly.

NOTE: In order to eliminate possible interference from the R.F. oscillator of the F.M. receiver, the manufacturer's instructions may call for the removal of the R.F. oscillator tube. In any case, you may check for interference of the local R.F. oscillator by rotating the tuning dial of the F.M. receiver while observing the oscillograph pattern and watching for distortion of the response curve or the presence of extraneous "pips".

With all other connections, controls, and switches set up in accordance with Section 5A - (Preliminary set up Procedure), with the "SWEEP WIDTH" control set to approximately 200 KC., and BOTH THE "R.F. LEVEL" and "OUTPUT CONTROL" set to maximum, the main tuning dial of the E-400 should be set to the I.F. frequency (10.7 MC. for this example). The response curve of the I.F. stage should then appear on the oscillograph screen.

A dual pattern similar to Fig. 5 will probably result: The two patterns can be superimposed by adjustment of the "PHASE CONTROL". After the pattern is adjusted for phasing, the "OUTPUT CONTROL" setting should be reduced to a minimum point, consistent with a clearly defined pattern.

If desired the blanking switch can be put on thus eliminating one of the traces and also producing a zero base line.

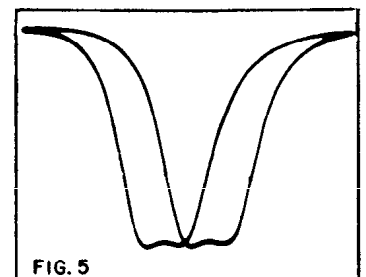
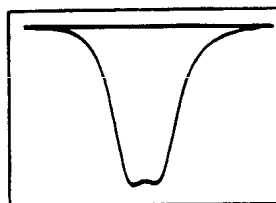
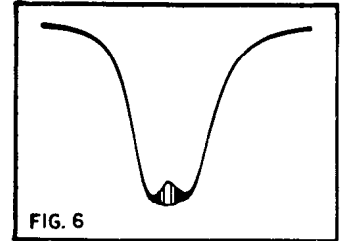


FIG. 5

If the normal RMA recommended resonance point of this stage is specified by the Manufacturer to be 10.7 MC., a 10.7 MC crystal (if available) may be inserted into any one of positions 1 through 4 of the E-400 crystal socket. With the "CRYSTAL SELECTOR" switch rotated to the proper position, the "CRYSTAL MARKER" "ON-OFF" switch is thrown to the "ON" position. Adjustment of the "MARKER AMPLITUDE" control will then bring into view on the oscillograph screen a discernible "pip" or marker similar to Fig. 6. It will be noticed that distortion of the response curve may occur if the "MARKER AMPLITUDE" control is turned too far. The marker amplitude should always be adjusted for a minimum size marker or "pip" consistent with visibility.



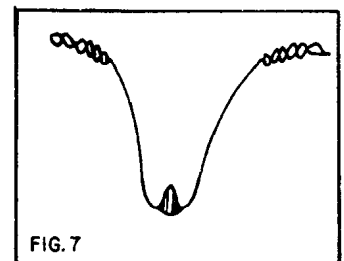
In some instances more than one "pip" or marker may be observed on the response curve; the additional "pips" may be caused by extraneous beats or signals within the receiver. In order to identify the actual crystal "pip", the "CRYSTAL MARKER" toggle switch should be thrown "ON" and "OFF" once or twice. The "pip" which appears and disappears simultaneously (in most cases) with actuation of the "ON"- "OFF" switch is the proper "pip".

The I.F. transformer primary and secondary should then be adjusted until the "pip" locates at the center of the pattern (see Fig. 6). Before attempting the next step (adjusting the shape of the response curve) the operator should determine the recommended shape and bandwidth as specified by the Manufacturer. For this example, a double hump type of curve and a 150 KC. overall bandwidth will be assumed as the manufacturer's example.

Unless the operator has available two additional crystals, one 75 KC. below 10.7 MC. and one 75 KC. above 10.7 MC., he will use his standard A.M. generator (such as E-200 or E-200-C) as a Variable Frequency External Marker Generator.

NOTE: (See Page 23) for instructions covering calibration check of the A.M. Generator. An alternative method is suggested on Page 27.

With the A.M. Generator connected as illustrated on Page 7 AND with the internal crystal marker still operating ("pip" on screen), rotate the tuning dial of the Variable Marker Generator until its "pip" also appears on the response curve. Continue to rotate the Variable Marker Generator dial until the two "pips" coincide. Exact superimposition will be evidenced by the appearance of "wiggles" at either end of the response curve (see Fig. 7) caused by low frequency "beat" between the two "pips".



The reading on the dial of the Variable Marker Generator should be on or close to 10.7 MC. The operator then should set the Variable Marker Generator to 10.7 MC. plus 75 KC. (10.775 MC.), resulting in a picture similar to Fig. 8. Should the 10.775 MC. marker fall too low down on the curve or too close to the 10.7 "pip", the primary and secondary of the I.F. transformer should be adjusted to coincide with the Manufacturers' illustration. As a check, the Variable Marker Generator should then be shifted to 10.7 MC. minus 75 KC. (10.625 MC.) and the position of the "pip" should be noted. The 10.625 MC. "pip" should locate symmetrically with respect to the 10.775 MC. "pip". (See Fig. 9), unless specific instructions are to the contrary.

IMPORTANT NOTE: While it is true that adjustment for the proper shape and band width of the response curve is an important alignment goal, the operator should not unduly sacrifice sensitivity or gain of the I.F. stage in an attempt to obtain unusually broad response. Therefore, when adjusting the I.F. transformer for 150 KC. response (for example), the operator should attempt to obtain both the "tallest" (highest gain) pattern on the oscillograph screen commensurate with the proper band width.

With the particular I.F. stage completely aligned, the next step requires that the "HIGH" terminal of the E-400 termination box be connected to the grid of the next I.F. stage. (Fig. 2). This stage and the remainder of the stages should then be aligned in accordance with the manufacturers' instructions.

NOTE: As the output of the E-400 is progressively shifted to the grid connections of preceding stages, the oscillograph remains connected across the limiter grid-leak resistor (Fig. 4). As the picture becomes progressively larger on the oscillograph screen, the setting of the E-400 "Output Control" should be reduced, NOT the Vertical gain of the oscillograph! The final I.F. adjustment is usually made with the output of the E-400 connected to the mixer grid of the first detector. If necessary, one or more of the intervening I.F. stages may then be slightly readjusted to obtain a response curve which most closely approximates the shape and bandwidth as recommended by the manufacturers' instructions, and whose amplitude on the screen of the oscillograph is the maximum obtainable.

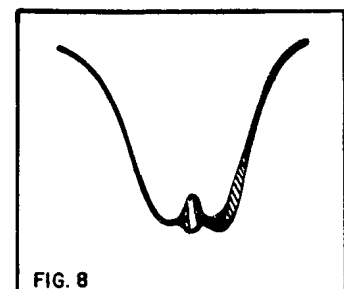


FIG. 8

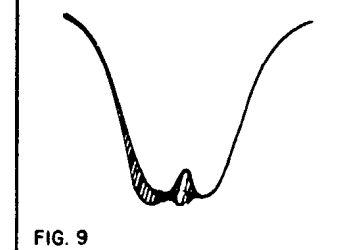


FIG. 9

(B) Discriminator Alignment

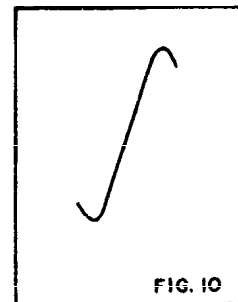
When a frequency modulated signal from an F.M.-I.F. system is applied to a discriminator, a voltage will be developed across the discriminator load resistor(s). As the frequency of the frequency modulated signal shifts from the mean carrier frequency at any one instant to a higher frequency, an output voltage develops across the discriminator load resistors, having a particular polarity with respect to ground. At the next instant, we will assume that the frequency of the signal being transmitted by the I.F. stages shifts back to the mean carrier frequency. At that instant, the voltage at point "X" would become ZERO. (Fig. 4).

At the next instant, we will assume that the F.M. Signal being transmitted to the I.F. stage shifts to a frequency lower than the mean carrier frequency. The voltage at point "X" would then become of opposite polarity.

From the above brief analysis, it is seen that the application of a frequency modulated signal to a discriminator produces an alternating voltage across the discriminator load resistors whose frequency is determined by the Rate of Frequency Change of the F.M. Signal, and whose amplitude is dependent upon the degree of frequency shift of the F.M. signal.

Fig. 10 illustrates the normal shape of the voltage curve or path of operation of the discriminator output when an F.M. signal is applied to the input of the discriminator.

Unless the receiver I.F. stages are completely out of alignment, the output of the E-400 should be connected between the grid of the first or second I.F. tube and ground, as a signal injection point. Should the I.F. transformers be misaligned as to attenuate the input signal to a very great degree, the output of the E-400 may be injected into the grid of the limiter tube, if such will produce a discriminator pattern of reasonable size on the oscilloscope.



NOTE: In all cases, where maximum output is required from the E-400 (for badly misaligned receivers), the termination switch should be thrown to the "OUT" position. It should be noted that at the higher frequencies, (above approximately 80 MC.), the termination switch should preferably be left in the "IN" position to minimize standing wave radiation effects.

Once the typical discriminator pattern is obtained on the oscilloscope (Fig. 10), a 10.7 marker signal may be applied. If the discriminator is properly aligned, a marker or "pip" will be obtained as indicated in Fig. 26P.

It will be noted that the marker "pip" at the center point of a properly aligned discriminator pattern will be difficult to discern. In order to more clearly observe the location of the marker or "pip", the operator may reduce the setting of the "SWEEP WIDTH" control to a point where only the center portion of the discriminator curve (with its "pip") is visible on the screen. If such is done, the resulting expansion of the central portion of the discriminator curve produces a more pronounced "pip" (of the type noted in Fig. 26Q). This type of "pip" as will be noticed, is different from the usual type of marker or "pip" in that the actual center of the marker is represented by the straight line portion of the "wiggly" line. This is related to the fact that the discriminator output voltage is ZERO at exact mean I.F. frequency.

If a variable marker generator such as Series E-200 or E-200C is used to produce the marker pip, the location of the pip at the center of the "S" curve can be easily determined as follows:

- (a) Set the E-200C to "Modulated RF" and apply approximately 50% modulation through adjustment of the "Mod. Control".
- (b) This modulated marker will produce obvious "wiggles" at the ends of the "S" curve whenever the pip is on the curve at any point OTHER THAN THE MIDPOINT. As the pip locates into the center of the "S" curve the "wiggles" will disappear.

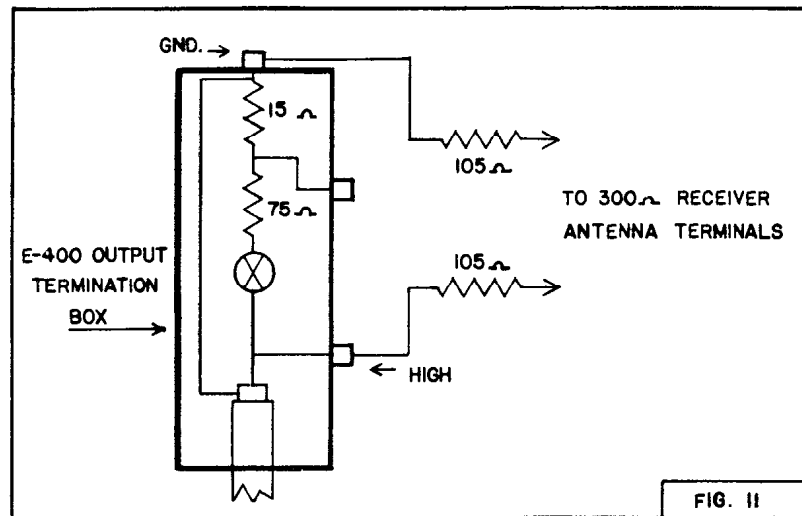
Next, the frequency of the Variable Marker Generator (still connected in the same fashion as in the I.F. alignment procedure previously covered) is set (for example) to 10.7 MC, plus 75 KC. (10.775 MC.) and the position of the resulting "pip" on the discriminator curve is noted. (See Fig. 26R). If the manufacturer's instructions do call for a "pip" 75 KC. higher than the mid frequency to locate at the extreme top of the curve, the discriminator transformer should be adjusted to achieve this result. The Variable Marker Generator should then be set to 10.7 MC. minus 75 KC. (10.625 MC.) and the location of the resultant "pip" on the curve should also be noted. This "pip" should locate symmetrically with respect to the 10.775 MC. "pip". Adjustment of the primary of the discriminator transformer will, in most cases, affect the overall amplitude of the discriminator curve and should be set for maximum on the oscillograph screen.

It is very important that the operator adjust the discriminator response for linear symmetrical response inasmuch as faithful reproduction of the frequency modulated signal is greatly dependent upon the response of the discriminator output.

NOTE: Fig. 26S illustrates the "double trace" system of checking symmetry of the discriminator Pattern. This method merely involves use of the oscillograph internal horizontal sweep system instead of the "Hor. Sweep" output of the E-400. It requires adjustment of the oscillograph horizontal sweep to approximately 120 cycles per second (or double the sweep frequency). The "crossover" point of the two curves can be adjusted by variation of the E-400 main tuning dial. The discriminator transformer is then adjusted so that a symmetrical picture is obtained. This method is in general, no more useful than the usual single-trace method previously described.

(C) Oscillator Alignment

The adjustment of the oscillator in an F.M. receiver is quite similar to the adjustment of the oscillator stage in A.M. receivers. The basic procedure is detailed as follows: With the tuning dial of the F.M. receiver set to 104 MC., for example, the output of the E-400 is connected to the antenna terminals of the receiver through a matching network illustrated in Fig. 11.



Assuming that the impedance of the antenna input of the receiver is 300 ohms and observing that the "High" output impedance (termination of the E-400 output cable) is 90 ohms, it is obvious that a degree of Mismatch will occur without the use of the matching network. To approximate an appropriate match, two carbon resistors (value approximately 105 ohms) are connected between the output cable of the E-400 and the receiver antenna terminals. A study of Fig. 11 will reveal that the impedance of the output cable of the E-400 "looks" like approximately 300 ohms to the receiver antenna input (105 ohms plus 90 ohms plus 105 ohms = 300 ohms), and that the impedance, "looking" out of the E-400 output cable is sufficiently high so as not to seriously disturb the output cable termination.

The "BAND SELECTOR" switch of the E-400 is rotated to Band "C"; the "Sweep Range" control is set to approximately 200 KC; the termination box switch is set to "IN", and the main tuning dial of the E-400 is set to 104 MC.

If the receiver oscillator is adjusted properly a 60 cycle low frequency note will be heard in the speaker of the receiver. If the note is not apparent, the oscillator will require adjustment. Tracking of the entire dial should be otherwise performed by the use of the usual A.M. technique and in accordance with the manufacturers' instructions.

Another method frequently recommended in the receiver manufacturers' instructions involves the use of an unmodulated R.F. signal and V.T.V.M., detailed as follows:

1. The "BAND SELECTOR" of the E-400 is rotated to Band "C"; the "SWEEP RANGE" control is set to "DEV.OFF"; and the main tuning dial of the E-400 is again set to about 104 MC.
2. The output of the E-400 is connected to the antenna terminals of the receiver through the impedance matching resistors.
3. The V.T.V.M. is connected across the leak resistor in the grid circuit of the limiter stage.
4. If the oscillator of the receiver is "in line", a maximum reading on the V.T.V.M. will be obtained when the tuning dial of the receiver is set to the same frequency (104 MC) as the E-400.
5. As in the previous procedure, tracking of the entire dial will then be performed using the usual A.M. techniques.

NOTE: The only difference between the two methods described above involves, in the first case, use of a frequency modulated signal and an audible indication; and in the second case, an unmodulated R.F. signal and a V.T.V.M. peak indication.

Other similar methods include the following:

1. The use of unmodulated R.F. signal and a minimum indication on a V.T.V.M. connected across the discriminator load resistors.
2. The use of a frequency modulated or Swept signal from the E-400 and a visual indication either from the grid resistor of the limiter stage or from the load resistors of the discriminator stage.

(D) Overall Check of R.F. and I.F. stages

As a double check of the combined operation of the R.F. and I.F. stages, the oscillograph may be connected in the grid circuit of the limiter stage as illustrated in Fig. 4 using the 25,000 to 250,000 ohm carbon isolating resistor. The output of the E-400 is injected into the antenna terminals (again using the 105 ohm matching resistors). With the dial of the E-400 set to selected frequencies and the dial of the receiver also set to approximately those same selected frequencies, the resultant wave shape on the oscilloscope may be examined for comparison with the curves recommended in the manufacturers' instructions. With the E-400 still connected to the antenna terminals of the receiver, the oscillograph may then be shifted to the output of the discriminator (See Fig. 4). Using the same procedure just outlined for overall R.F.-I.F. check, the discriminator wave shape may be double-checked on an overall operational basis.

* * * * *

2. TELEVISION RECEIVERS

The 5 basic steps in the alignment of television receivers (except inter-carrier type) are listed as follows:

- (A) Video (picture) I.F. traps
- (B) Picture I.F. transformers
- (C) Sound discriminator
- (D) Sound I.F. transformers
- (E) R.F. adjustment
- (F) R.F. Oscillator adjustment

NOTE: As stated previously, it is again strongly emphasized that the operator become well schooled in the theory and practical aspects of television receiver servicing and alignment before attempting test and repair of television receivers.

The alignment descriptions which will follow are necessarily general in character, and should not be followed explicitly in the alignment of any one particular model of television receiver.

ALWAYS FOLLOW THE MANUFACTURER'S DETAILED ALIGNMENT AND TEST PROCEDURES WHEN SERVICING A TELEVISION RECEIVER.

(A) Alignment of Picture (Video) I.F. Traps.

A picture I.F. trap basically consists of a tuned circuit adjusted to resonance at a particular frequency. Most manufacturers' instructions will call for alignment of these traps using a fixed unmodulated R.F. signal as an injection source, and a Vacuum Tube Voltmeter as an indicating device. In such an alignment setup, the I.F. trap is to be adjusted for minimum indication on the Vacuum Tube Voltmeter.

If the operator has available an accurate signal generator such as the PRECISION Series E-200 or E-200-C, he may use this generator as the signal source. However, should any question arise concerning the calibration accuracy of the A.M. signal generator, the operator may utilize special facilities included in the E-400, which provide for crystal controlled R.F. output for trap alignment or alternative means for crystal controlled calibration of the standard A.M. signal generator.

The E-400 crystal marker oscillator serves a dual purpose providing both an internal marker source for visual alignment purposes, and a crystal controlled R.F. signal for external applications such as trap adjustment, signal generator calibrations, etc.

The test equipment setup for trap adjustment with the use of crystals is detailed as follows:

1. The "BAND SELECTOR" switch of the E-400 is rotated to "XTAL ONLY" position. Crystals of the proper frequencies for trap alignment are inserted into the multiple crystal socket.

The Marker Cable connects to the "EXT. MARK. INPUT" - "CRYSTAL MARK. OUTPUT" connector on the panel of the E-400. The Cable Connector Adapter furnished with the E-400 is connected to the free end of the "Marker Cable". The two alligator clip leads of the Adapter may then be used for injection into the receiver trap circuit.

2. A Vacuum Tube Voltmeter (such as PRECISION Series EV-10A) is then connected across the video second detector load resistor. With the unmodulated R.F. signal of proper frequency applied to the trap under alignment, the trap trimmer or slug should be tuned for a minimum indication on the Vacuum Tube Voltmeter.

3. The same procedure should be carried out for all the picture I.F. traps listed in the manufacturers' instructions, using each time, the proper crystal for each trap frequency therein specified.

An alternative method of adjusting or re-checking traps is described as follows:

After a complete video I.F. alignment has been completed and a picture I.F. pattern is obtained on the oscillograph (procedure to be described on the following pages), the External Variable Marker Generator may be used to obtain a traveling "pip" on the oscillograph pattern. As the traveling "pip" approaches points on the picture I.F. curve designated as trap points, the "pip" will decrease in amplitude and finally disappear at the trap point.

If, now, the sweep width is progressively reduced to zero, while the tuning dial of the E-400 is adjusted as required to keep the trap response in the center of the scope screen, it will be noted that the marker begins to appear visible in the trap. Then, if the output of the generators and the input sensitivity of the scope are increased to maximum, the marker in the trap will become quite visible. The trap is adjusted, of course, to make this marker as small as possible.

Some receivers make use of double traps to obtain very great rejection of an unwanted frequency. In this case, it may be found that the total attenuation is sufficient to reduce the marker to zero when both traps are tuned near the marker frequency. To avoid doubt in this case, adjust the second trap by moving the signal injection point beyond the first trap, but before the second trap.

A more rapid, if somewhat less accurate method of determining the trap frequency consists of "rocking" the dial of the E-200C to make the marker pass through the trap and appear, in turn, on either side of the trap frequency. The trap frequency, of course, is half way between the frequencies at which the marker becomes visible on either side.

NOTE: If crystals at the trap frequencies are not available, you may employ your standard A.M. Signal Generator instead of the crystal oscillator of the E-400. If such is done, it is desirable that the calibration of the A.M. Signal Generator be checked as described on Pages 23 and 24 of this manual. (For alternative method see Page 27).

Inasmuch as the output of the E-400 is unmodulated R.F., WHEN the "Sweep Range" switch is rotated to "DEV. OFF", this unmodulated output may also be used for trap alignment instead of either the standard A.M. Generator or the internal crystal oscillator.

The TV station signal will also mark the sound trap frequency quite satisfactorily, as explained on Page 18.

(B) Video I.F. Transformers

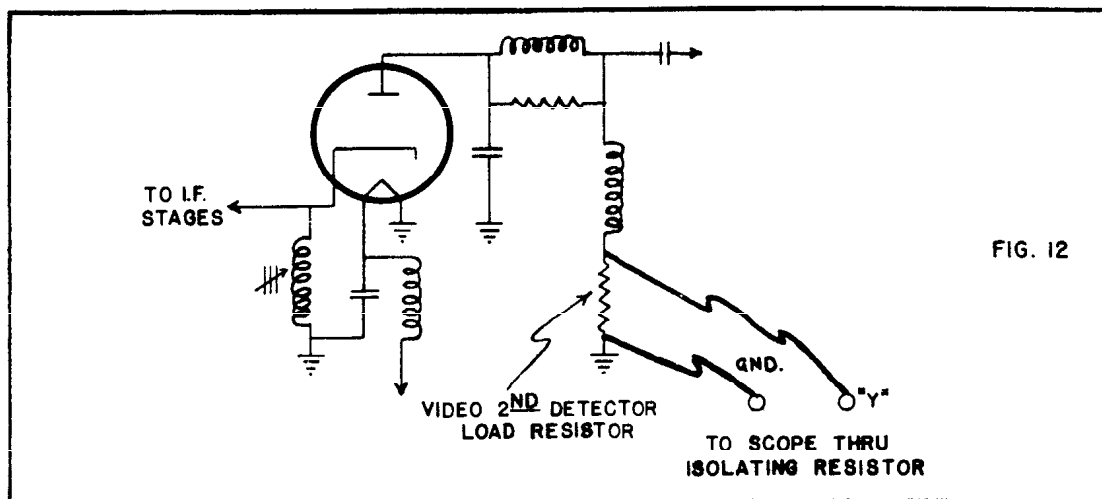
In order to obtain the unusually wide band width required in a television picture (video) I.F. system, it is usually necessary for the television receiver designer to employ "staggered" tuning (i.e., each picture I.F. stage is tuned to a slightly different frequency) or else resistance loaded tuned circuits. The manufacturers' instructions should therefore always indicate the individual alignment frequency of each Video I.F. stage. After each stage has been aligned to its specific frequency, the overall picture obtained for the total I.F. system will (on wide response type television receivers) appear similar to Fig. 27A.

An alternative to visual alignment of each video I.F. stage is occasionally described by the manufacturer, involving the use of an unmodulated R.F. Signal Generator and a Vacuum Tube Voltmeter for simple peaking adjustments of individual stages. If this method is used, the operator should not neglect to obtain an overall visual alignment picture by coupling the E-400 to the converter by means of several turns of wire wrapped around the converter tube and by connecting the Vertical terminals of the oscillograph (through a 25,000 to 250,000 ohm isolating resistor) across the video second detector load resistor. Using this overall response check procedure, the operator then may make slight individual adjustments of the I.F. transformers to obtain the required overall Video I.F. response curve.

NOTE: The typical video I.F. response curve illustrated in Fig. 27A does not necessarily represent the pattern which will be obtained on all Picture I.F. systems. Some of the less expensive, less complicated television receivers with small-size Cathode Ray tubes, do not incorporate "flat top" picture I.F. response curves and furthermore may not produce the obvious trap dips at either end of the response curve as illustrated in Fig. 27F. It is therefore imperative that the operator first consult the manufacturers' instructions to ascertain the type and shape of overall response curve of the particular television receivers being adjusted.

A typical overall video I.F. response curve check is detailed as follows:

1. Connect the Vertical terminals of the oscillograph (using the aforementioned carbon isolating resistor) across the picture second detector load resistor. (Points "Y" and "GND", Fig. 12).



2. Connect the "GND" post of the E-400 output cable of the chassis of the TV receiver, and the "HIGH" terminal of the E-400 output cable to a simple wire loop which is slipped over the TV set Converter tube.
3. Disable the local oscillator. Removal of oscillator tube is most practical except in AC-DC receivers and in combined mixer-oscillator systems.
4. Set the "Termination Switch" on the E-400 output cable to "IN".
5. The "BAND SELECTOR" and main tuning dial of the E-400 should be approximately set to the picture I.F. center frequency as specified by the set manufacturer. (Let us assume it to be 25.75 MC.)
6. Set the "SWEEP RANGE" switch of the E-400 to the "0-15 MC" position and "SWEEP WIDTH" control to approximately 10 MC.
7. If the manufacturers' instructions call for adjustment of the receiver I.F. bias to a specified voltage, the front control on the TV receiver, which adjusts this bias, should be set to the required value using a Vacuum Tube Voltmeter (Precision Series EV-10A.) See Miller Effect Page 16.

IMPORTANT NOTE: It will be noticed by the operator that manual adjustment of the I.F. bias control (sometimes labeled "Contrast" or "Picture") on the TV receiver will act as an attenuation control, reducing the strength of the input signal from the E-400, in addition to the "Output Control" and "R.F. Level" control of the Series E-400.

8. If the set uses AGC, over-ride this bias by a cable plugged into the "AVC Voltage" jacks of the E-200-C. See Fig. 2.

As the "OUTPUT CONTROL" of the E-400 is adjusted, the overall Video I.F. response curve will be obtained on the screen of the oscillograph. (See Fig. 27A).

It will be noted that the flat top portion of the response curve will become excessively flat and the picture itself will distort to a great extent if the "R.F. LEVEL" and "OUTPUT CONTROL" are advanced too far. (See Fig. 27D). The proper adjustment with these controls is at a point below that which produces distortion of the response curve.

The introduction of "pips" or markers is then necessary. Again, as in the case of F.M. alignment, an external Variable Frequency Marker Generator (such as PRECISION Series E-200 and E-200-C) may be used as the marker source, or the internal Crystal Marker oscillator may be used as an accurate signal source, provided crystals of the proper frequency are available for the operation. (See Page 24 re crystal requirements).

(The setup for use of the external Variable Marker Generator is detailed in Fig. 2).

The first marker which usually is superimposed on the response curve, is the so-called mid-point marker which, in the case under discussion, would be 25.75 MC. This point is indicated on Fig. 27A. The operator will observe that this 25.75 MC marker does not actually locate at the physical center of the response curve. Nevertheless, this point is usually referred to as the "mid-point" marker of the video I.F. response curve. This portion of the response curve usually is practically a vertical line thereby reducing the visibility of the marker on this section of the curve. In order to increase the visibility of the marker, the setting of the "SWEEP WIDTH" control should be slowly reduced, expanding that portion of the curve until that portion only occupies the full width of the

oscilloscope screen. (The main tuning dial may require a slight readjustment in order to keep the required portion of the curve at the center of the oscilloscope screen).

THIS METHOD OF "EXPANDING MARKERS" MAY BE USED IN ANY CASE WHEREIN THE OPERATOR DESIRES TO DEFINE ANY MARKER OR "PIP" MORE CLEARLY.

Other markers, for example, at 22.3 MC. and at other check points as recommended by the manufacturer, may be introduced as a check of the overall response curve shape.

NOTE: The manufacturers' instructions may recommend that the oscillator tube be removed and/or that circuits in the R.F. end be shunted or by-passed in order to eliminate interference with the video I.F. response curve. A quick check may be made by the operator to determine the presence or absence of interference, by rotating the channel selector switch on the front of the TV receiver while watching the I.F. response curve. As interference occurs, radical changes will be noted in the shape of the response curve on the oscilloscope screen. I.F. alignment should only be performed with station selector switch set to a non-interfering position.

It must be observed that set manufacturers almost invariably publish response curves which are primarily suitable for local reception (strong signal conditions). In fringe areas, the operator should modify the procedure suitably as follows:

- (1) Align the receiver with the contrast control set to $3/4$ maximum, or maximum, depending upon expected signal level. This precaution is necessary because most receivers will show a different response curve at high gain, due to the so-called Miller Effect.
- (2) Insert the picture carrier marker or "Pip" on the curve as usual
- (3) Narrow the bandwidth of the receiver to approximately half the band-pass recommended for local reception, and place the picture carrier pip near the top of the curve. See Fig. 13. This procedure allows the sound and picture to "track" under conditions of low signal level, and produces satisfactory picture and sound under conditions where the usual type of alignment would result in "snowy" pictures and/or loss of sound. It must be emphasized that "fringe alignment" causes degradation of picture quality under high signal level conditions.

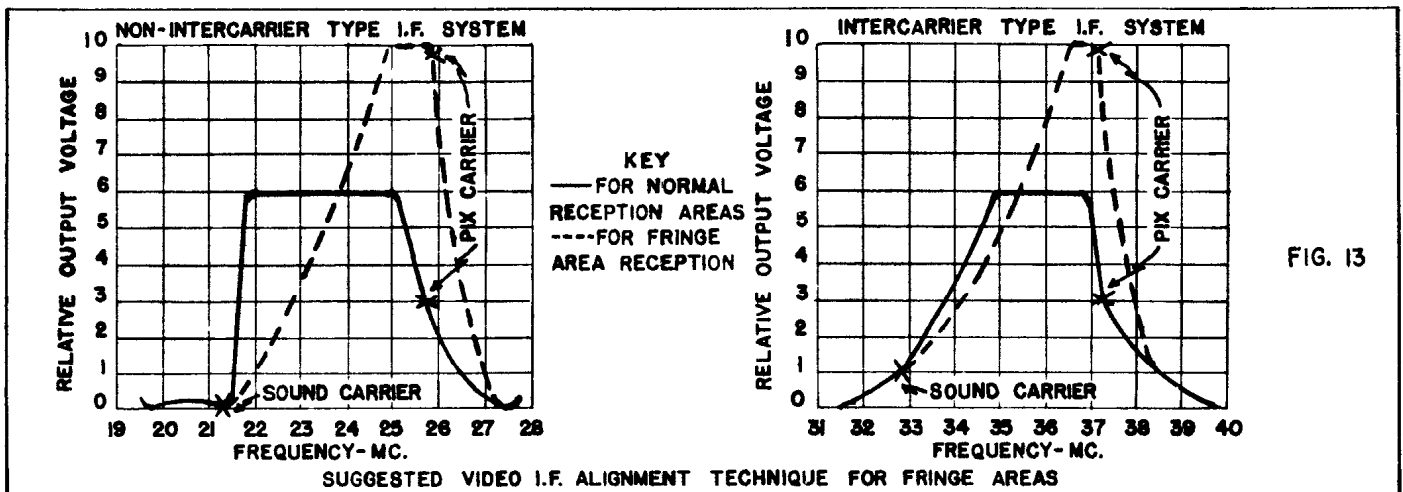


FIG. 13

NOTE: Operators frequently ask why the ideal response curve cannot be obtained, no matter how carefully instructions are followed. This arises from COMPONENT TOLERANCES in the receiver. The plate resistance, amplification factor, etc., of tubes will vary widely; tuned circuits vary in Q; resistors and capacitors vary from 10% to 20%; lead dress varies from chassis to chassis. As a result, it is usually impossible to obtain the IDEALIZED response curve. Following is a discussion of response variation in terms of decibels.

The serviceman should remember that the eye responds like the ear in many respects; that is, the eye response is to be considered in terms of decibels (DB). As in audio work, a video signal will be judged twice as bright if increased 6 DB. Likewise, a video signal will be judged half as bright if decreased 6 DB. One DB is the smallest change in a video signal that the eye can detect, even under the most favorable circumstances.

Therefore, a response curve does not have to be absolutely flat. It is true that a perfectly flat response curve will make the high-frequency picture elements equally bright as the low-frequency picture elements. But, on the other hand, note these facts:

- (1) A perfectly flat response is usually impossible to obtain.
- (2) A variation in output voltage of as much as 25% actually represents only 2 DB, which variation passes unnoticed unless the observer is looking very carefully under ideal test conditions.

This, then, means that the operator who wishes to evaluate alignment-curve variations, should make a habit of evaluating them in terms of decibels to arrive at a meaningful conclusion.

(C) Sound Discriminators

It is quite important that the sound discriminator in a television receiver be adjusted quite accurately inasmuch as the subsequent alignment of the R.F. oscillator will depend upon the alignment accuracy of the sound discriminator. A typical visual sound discriminator alignment procedure is detailed as follows and is quite the same procedure as outlined for F.M. receivers.

- (1) The vertical terminals of the oscillograph are connected across the load resistors of the discriminator output, in accordance with the manufacturers' instructions.
- (2) As in an F.M. receiver, the output of the E-400 is connected into either the grid of the I.F. tube preceding the discriminator, or to the grid of the limiter tube.
- (3) The main tuning dial of the E-400 is then set to the sound I.F. frequency specified by the manufacturer (let us assume 21.25 MC.).
- (4) With the "SWEEP RANGE" switch set to "0-1000 KC.", adjustment of the "SWEEP WIDTH" control will then bring the typical discriminator "S" pattern into view on the oscillograph.
- (5) A marker or "pip" at 21.25 MC. is then superimposed on the discriminator pattern (by use of either the internal crystal oscillator or the External Variable Frequency Marker Generator), and the sound discriminator transformer is adjusted, if such is required.
- (6) If the response of the discriminator is specified by the manufacturer to be, for example, 25 KC. either side of center (50 KC. total width) along the linear portion of the curve, markers may then be injected at 21.275 MC. and then at 21.225 MC. if the operator wishes to check the symmetry and bandwidth of the discriminator output.

(D) Sound I.F. Transformers

The alignment of sound I.F. transformers in the TV receiver is practically identical to the alignment of the I.F. transformers in the ordinary FM receiver, with the exception that the sound I.F. bandwidth in television receivers is somewhat less than that used in regular F.M. sound receivers.

- (1) If the sound system is of the limiter-discriminator type, the oscillograph is connected across the grid resistor in the limiter stage.
- (2) The "HIGH" termination of the E-400 output cable is connected to the grid of the sound I.F. nearest the discriminator and the I.F. transformer is adjusted to obtain the response curve shape specified by the manufacturer.

Should the manufacturer recommend progressive adjustment on the I.F. transformers (similar to the straight F.M. receiver procedure) the output of the E-400 will, of course, be injected into the I.F. grids progressively up towards the converter stage, with each transformer receiving its progressive individual adjustment.

The center-point marker (21.25 MC. for example) is injected to allow for center alignment of the I.F. response curves. Side markers may then be injected (if desired) on either side of the center marker to allow for proper adjustment of the "flat top" bandwidth of the response curves.

(E) R.F. and Converter Adjustment

Two methods of television receiver R.F. stage alignment are currently in use:

- (1) The first type of adjustment suggests that the operator check the R.F. channel frequency (through a matching network) at the antenna terminals and obtain the response curve of the R.F. unit ONLY, on the screen of the oscillograph.
- (2) An alternative method of R.F. adjustment involves an indirect check of the front end response curve by observation of the video I.F. response curve with Sweep Generator signal injected into the antenna terminals of the television set.

The second method is an indirect method and effectively checks only the picture response of the front end. It is accomplished as follows:

The operator first double checks the video I.F. response curve wave shape (which has already been aligned) by connecting the E-400 and the oscilloscope for normal video I.F. alignment. With the shape of the video I.F. response curve thus pictured by the operator, the tuning dial of the E-400 is then set to the desired R.F. channel frequencies with the channel selector of the television set to the corresponding channel numbers. The E-400 output is fed to the antenna terminals of the set (through a matching network) as shown in Fig. 11, with the scope still connected across the Video 2nd detector load resistor. The video I.F. pattern thus produced will now be influenced by the response of the front end. ("Overall Response Curve"). Should the I.F. response curve differ appreciably from the response curve pattern obtained on the

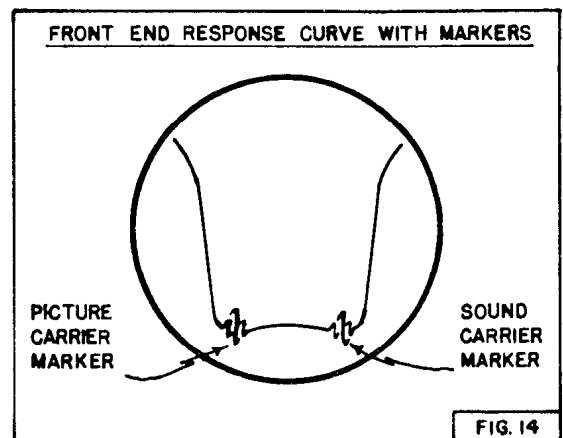
straight Video I.F. check, the appropriate trimmers and inductances must be readjusted in accordance with the manufacturers' instructions such that the I.F. wave shape under this condition conforms as closely as possible to wave shape pattern noted during the straight video I.F. check. To assist in checking this "overall response pattern", markers can be inserted using one of three methods, described as follows:--

1. The markers can be injected at I.F. frequency for this particular test, since it is immaterial whether the marker is picked up by the circuits at station frequency and subsequently beat down, or whether the marker is injected at the beat down (I.F.) frequency. To inject the marker at I.F. frequency, use the "chassis" method as explained on Page 7.
2. The actual station carriers can be used to mark the sound and picture frequencies, as follows:
 - (a) Tune in a TV station on the receiver.
 - (b) Disconnect the antenna, and connect the sweep-alignment equipment.
 - (c) Hold the antenna near the antenna posts, or connect the antenna to the posts through high resistance.
 - (d) The picture carrier marker will now be seen. The sound carrier marker will now be seen. (The sound carrier marker will be visible as the fine tuning control is rotated.)
 - (e) Run the sound marker down into the sound trap by adjustment of the fine tuning control. The marker will disappear in the bottom of the dip caused by the sound trap, but reappears again on either side as the fine tuning control is varied. When the sound marker disappears completely in the trap, the picture marker should normally appear half way up the curve. If it does not appear half way up, the operator should next adjust the RF coils as required. In case these adjustments cause a dip, a hump, or slope to appear along the top of the overall response curve, it is understood that compromise adjustments will be required to obtain the best possible adjustment under the conditions of tube and component tolerances of the particular receiver. (Incidentally, this procedure for inserting markers by using the actual transmitter signal-is an excellent way of checking the receiver oscillator alignment itself).

The above method of frontend alignment adjustment is quite satisfactory for routine front end alignment. However, should the operator desire to align the front end by directly obtaining a response pattern of the front end on the oscilloscope the following procedure may be employed.

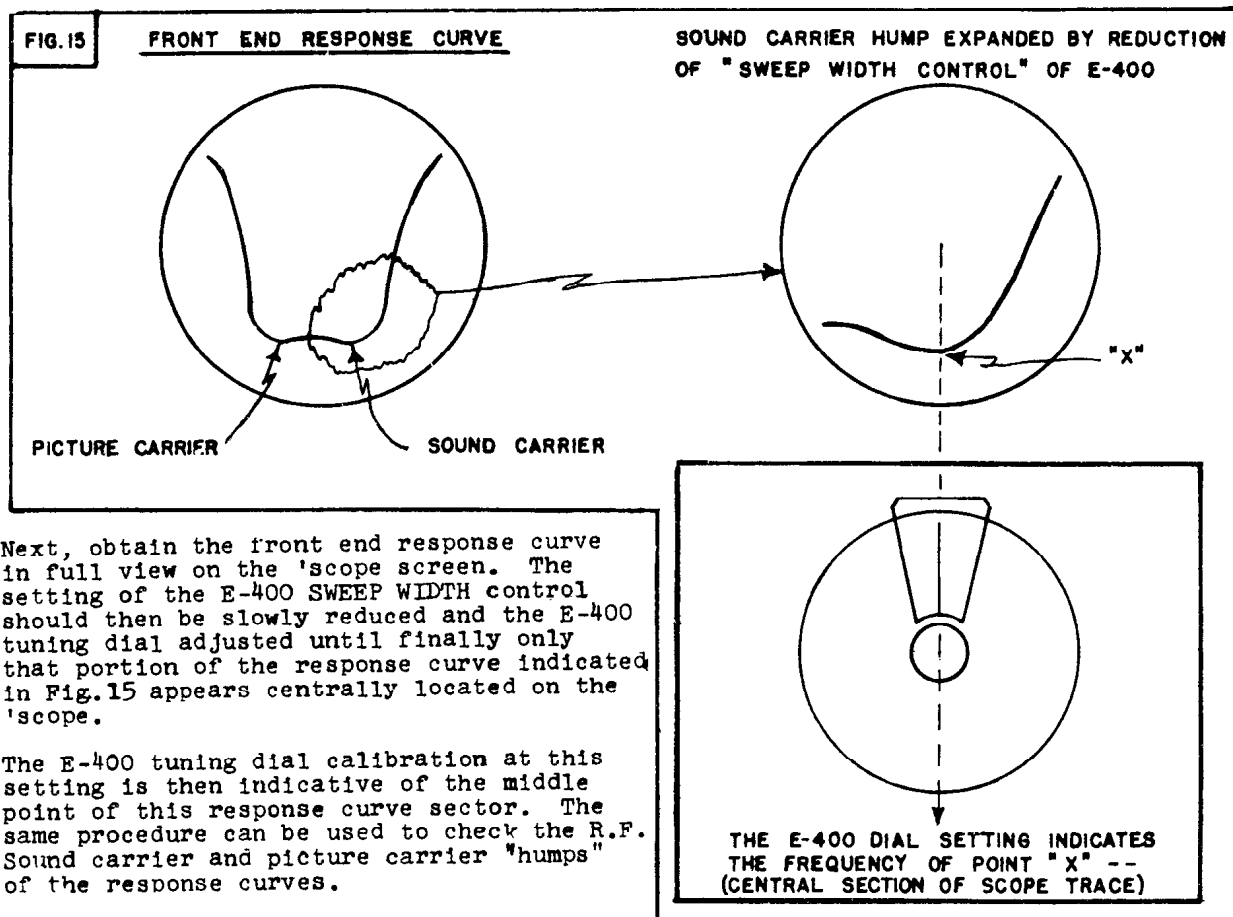
1. Connect the E-400 output termination box to the receiver antenna terminals thru the required matching network as illustrated in Fig. 11.
2. Connect the Vertical terminals of the 'scope to the take-off point in the converter circuit as detailed in the set manufacturers' instruction (Use a high resistance isolating resistor in series with the "Hot" lead of the 'Scope).
3. Set the I.F. bias (using a DC VTVM such as PRECISION Series EV-10A or EV-20) to the value prescribed by the set manufacturer; also note the manufacturers' instruction regarding temporary shunting of the 1st video I.F. circuit and/or reduction of local oscillator influence during these tests.
4. Set the E-400 tuning dial and the TV set channel selector to the frequency of the first channel (as prescribed by the set manufacturer) to be checked.
5. In most cases a broad band response curve (similar in the ideal case to Fig. 14) will be obtained. It may be necessary to use a high Vertical sensitivity setting of the 'scope to obtain a good-sized pattern due to the relatively low gain of the front end.
6. Should an accurate high frequency marker Generator be available to the operator, appropriate markers at the R.F. Picture channel frequency and the R.F. Sound channel frequency are then consecutively inserted. In the ideal case the markers should appear at the points indicated in Fig. 14. In practical applications, the response curve shape may differ considerably from the ideal example: the operator must refer to the response curves and associated marker location as illustrated in the TV set manufacturers' instructions.

Each channel is checked in similar fashion (E-400 tuning dial and Receiver Channel Selector set to the desired channel) and the appropriate inductance adjustments are made if required to correct the response curve shape, when necessary, as detailed by the set manufacturer.



7. If a source of high frequency Marker signals is not available, the following method can provide a sufficiently satisfactory wave shape check:

- (a) With the Vertical Gain control of the 'Scope set to Zero, locate the 'scope trace in the exact center of the screen.



- (b) Next, obtain the front end response curve in full view on the 'scope screen. The setting of the E-400 SWEEP WIDTH control should then be slowly reduced and the E-400 tuning dial adjusted until finally only that portion of the response curve indicated in Fig.15 appears centrally located on the 'scope.
- (c) The E-400 tuning dial calibration at this setting is then indicative of the middle point of this response curve sector. The same procedure can be used to check the R.F. Sound carrier and picture carrier "humps" of the response curves.

(F) R.F. Oscillator Alignment

Methods for aligning the oscillator will vary from one manufacturers' instructions to another. The simplest, most frequently used method is described as follows:

1. Connect the Vertical terminals of the oscillograph across the discriminator load resistors.
2. Connect the output of the E-400 output cable to the antenna terminals of the TV receiver (using the impedance matching network illustrated in Fig. 11).

NOTE 1: The "Termination Switch" should be thrown into the "IN" position. If sufficient attenuation cannot be obtained using the "HIGH" terminal of the E-400 output cable, the "LOW" terminal should be used.

NOTE 2: The manufacturer will probably call for adjustment and check of the oscillator beginning with a certain specified channel, with the remainder of the channels to be switched in a specified order.

3. If the TV set includes a "Fine Tuning" knob, the instructions will probably call for this "Fine Tuning" knob to be set at mid-position as each channel is aligned.
4. The E-400 "SWEEP RANGE" switch is to be set to "0-15MC." and "SWEEP WIDTH" set to approximately 10 MC.
5. The main tuning dial of the E-400 is then set to the Sound channel frequency of the first channel to be aligned.

NOTE: If facilities for injection of high frequency markers are not available, the Dial of the E-400 itself may be used to check and align the R.F. oscillator. Therefore, with the main tuning dial set to the proper Sound channel frequency, a properly aligned R.F. oscillator will produce a discriminator response pattern CENTRALLY located on the oscillograph screen.

The station signal, if available, can be used as a marker, as explained on Page 18.

6. When checking the first channel, if the discriminator pattern is not centrally located on the oscillograph screen, adjustment of the appropriate oscillator trimmer is made in accordance with the manufacturers' instructions, until the pattern shifts to the center of the oscillograph screen.

7. The remaining channels are adjusted in similar fashion.

NOTE: It may be found that the "Fine Tuning" knob may require slight shift from its mid-way position in order to properly align all channels.

A variation of the above procedure is described as follows:

1. Connect a Vacuum Tube Voltmeter (Precision Series EV-10A) across the discriminator load resistors.
2. Connect the output of the E-400 output cable to the antenna terminals of the TV receiver (using the impedance matching network).
3. The E-400 "SWEEP RANGE" switch is set to "DEV. OFF". The output of the E-400 under these conditions is an unmodulated R.F. signal.
4. The main tuning dial of the E-400 is then set to the proper frequency for the first channel to be aligned.
5. If the oscillator is accurately aligned, a trial adjustment of the oscillator trimmers or slugs will cause the V.T.V.M. to vary from a negative voltage reading through a zero voltage reading and then to a positive voltage reading. The proper adjustment is one which yields a zero voltage reading. (Center point of discriminator response.)

NOTE: Should the oscillator trimmers or slugs be rotated to too great an extent, two false Zero V.T.V.M. readings can be obtained. A false zero reading falls outside of the discriminator response region. A check for the proper zero voltage adjustment is made by slightly varying the oscillator trimmer or slug to the left and to the right. If the oscillator is properly adjusted, a slight positive and negative V.T.V.M. reading will be obtained simultaneously with the aforementioned slight adjustment. The proper Zero adjustment falls in between the positive and negative V.T.V.M. readings.

It is seen that this latter method of adjusting or checking the R.F. oscillator is identical in principle to the first method outlined, but differs only in that the first method uses a Swept Signal and a Visual Indication, whereas the second method involves the use of an unmodulated R.F. Signal and a V.T.V.M. reading.

It is also noted that the oscillator adjustment for all channels depends (in both methods) wholly upon the accuracy with which the sound discriminator has been previously aligned.

Some manufacturers' instructions may also indicate another alternative means of alignment of the oscillator via the heterodyne frequency method. It is recognized, however, that the methods just outlined, are quite as satisfactory as the frequency meter method or other similar procedures.

* * * VI. INTERCARRIER APPLICATIONS * * *

The following instructions apply specifically to the intercarrier type of receiver, which differs from the conventional TV receiver in that both sound and picture frequencies are amplified together, in common amplifier stages. The basic steps in the alignment of intercarrier type receivers are listed as follows:

1. Over-ride of AGC bias.
2. Alignment of I.F. Transformers.
3. Alignment of Sound Circuits.
4. R.F. and Converter Alignment.
5. R.F. Oscillator Alignment.

NOTE: It must be strongly emphasized that great variation is encountered in circuit detail. Some receivers use ratio detectors, while others use gated beam detectors. Still others employ limiters and earlier types of discriminators. These alignment instructions are therefore general in character, and should not be followed explicitly in alignment of any one particular model of television receiver.

1. Over-ride of AGC Bias.

As shown in Fig. 2, an adjustable over-ride bias can be most conveniently obtained from the E-200-C. Note that the bias scale divisions serve as a guide, but not as a direct voltage indication. Always use a voltmeter to check the value of the over-ride bias voltage, and adjust to the value recommended by the receiver manufacturer.

2. Alignment of I.F. Transformers.

Because I.F. traps are not used in conventional inter-carrier receivers, alignment is a relatively simple procedure. There are two basic marker points on the curve:

- a) The sound-carrier marker is placed 10% up the curve.
- b) The picture-carrier marker is placed 50% up the curve.

NOTE: Some inter-carrier receivers are designed for local oscillator operation on the high side with respect to Channels 2-6, but on the low side with respect to Channels 7-13. In such case, the operator must endeavor to obtain complete symmetry of IF response, because the sound and picture I.F. carriers will reverse their positions during use of the receiver.

After the sound and picture carrier markers have been placed correctly on the curve, the operator should next check the pass band. In television work (unlike radio receivers), the pass band is defined as the number of megacycles between the half-voltage points on the response curve. To obtain maximum picture quality, the operator works for maximum band pass with the limitations dictated by the specified locations of the sound and picture carrier markers. The E-200-C is ideal for marking inter-carrier response curves, as well as for peaking individual stages as recommended by some manufacturers. The operator should note particularly that "peaking" can be carried out most expeditiously as follows:

- a) Set the E-200-C at the peaking frequency specified by the manufacturer for the particular stage. A marker appears on the response curve at this frequency.
- b) Next, adjust the slug or trimmer of the coil to be peaked, meanwhile observing the position of the marker on the graph screen of the scope. Note particularly that the shape of the curve changes during this procedure, but this is to be completely disregarded by the operator. The stage is peaked when the marker pip is at the highest point on the graph screen, no matter what shape the response curve may take. Subsequent stages are to be peaked in the same manner.
- c) After the peaking process is completed, it is essential to check the response curve for picture and sound carrier marker positions, as well as for band pass. Compromise adjustments can then be made, if required.

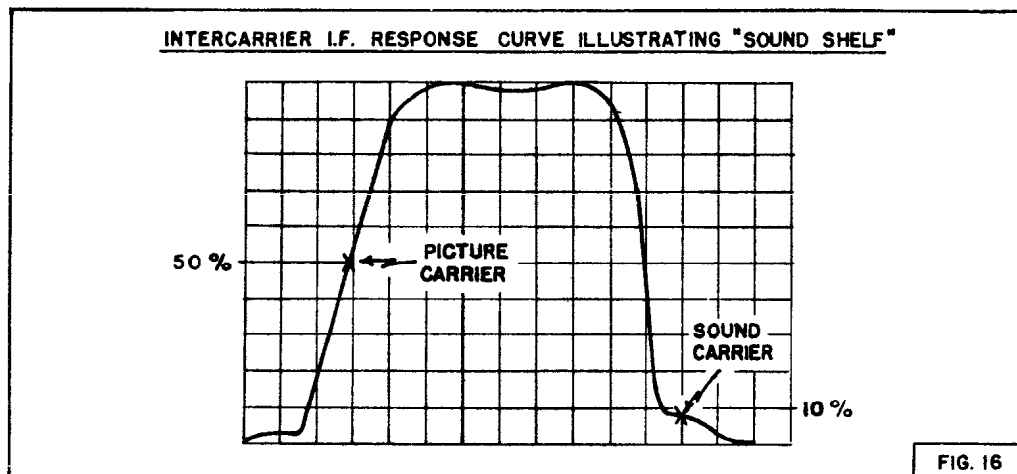
3. Alignment of Sound Circuits.

Because sound circuits vary greatly, only the underlying principles can be discussed here. Basically, the sound signal in an inter-carrier receiver is obtained by picking out the 4.5 MC beat between the sound and picture carriers of the TV station. This beat frequency is accepted by a 4.5 MC "trap", or by a tuned transformer.

Because this 4.5 MC frequency is determined by the spacing of the station carriers, it is not affected by the setting of the fine tuning control, and it is therefore absolutely essential to tune the sound circuits exactly to 4.5 MC, using the 4.5 MC crystal supplied with your E-400.

Careful adjustment of the FM detector circuit is required to eliminate or minimize "buzz" from the sound signal.

Sound Shelf: The better inter-carrier receivers provide circuits for obtaining a sound shelf on the response curve, as shown in Fig. 16. The sound carrier marker should be placed half-way along the shelf, as shown. This shape of response curve minimizes amplitude modulation of the FM sound carrier as it swings through its center frequency, and provides better sound quality.



In order to obtain a general idea of how the shape of the response curve affects the amount of A.M. in the 4.5 MC sound signal, the following facts should be noted:

- a. The 4.5 Mc sound signal is always amplitude modulated to some extent (buzz modulation) by the picture carrier, and this buzz must be removed by proper discriminator or ratio detector alignment, plus proper operation of the limiter when provided.
- b. If the sound carrier marker is placed well up on the response curve, the sound signal can become amplitude modulated up to 100%. This condition imposes practically impossible demands upon the FM detector system.
- c. If the sound carrier level is 10% of maximum, the sound signal is then amplitude modulated only 5%, approximately. Therefore, the sound carrier should be kept well down on the response curve to avoid "buzz", by giving the FM detector opportunity to operate properly.

Alignment vs. "Buzz"

The picture signal itself sounds like a rough 60-cycle buzz, as the service man can check with a pair of earphones connected into the video amplifier of the TV receiver. The conventional discriminator accept FM signals and rejects AM signals at the center point of the S curve, when properly aligned. To further reject A.M. signals (buzz) at other points on the S curve, a 4.5 Limiter-amplifier is used to clip the 4.5 Mc wave to a predetermined level.

It will be apparent that unless the S curve is shaped as recommended by the set manufacturer, with the 4.5 MC point exactly at the center, (using the 4.5 MC crystal) and unless the bias of the limiter is correctly set for the prevailing signal level, amplitude or buzz modulation will be present in the sound output circuits.

These AM rejection facilities are provided by more streamlined means in the case of ratio detectors and gated beam detectors. However, it will be apparent that these "simpler" circuits require the same care in alignment, if buzz is to be avoided in the sound.

4. RF and Converter Alignment

The RF or front-end adjustments can be made in the conventional manner, as explained on Page 17.

5. RF Oscillator Alignment

The RF oscillator has small effect on the sound signal in an intercarrier receiver. For this reason, one of the following methods will be found most suitable for adjustment of the local oscillator frequencies.

- a. Connect the E-400 to the antenna posts of the receiver and connect the ES-500 to the second-detector load resistor through an isolating resistor. Using the "chassis" method, inject a marker from the E-200C at the Video I.F. frequency. Set the E-400 dial to the PICTURE CHANNEL FREQUENCY and reduce the sweep width of the E-400 output to nearly zero. Then adjust the local oscillator of the receiver as required to center the marker on the screen of the 'scope. (The fine tuning control of the receiver should be set midway of its range while making this adjustment). This procedure can then be repeated on each channel, in the order recommended by the set manufacturer.
- b. Obtain the over-all response curve (E-400 antenna terminals, 'scope at second detector load resistor) and inject an unmodulated signal into the front end at the sound carrier frequency for the particular channel. Next, adjust the local oscillator until the sound marker appears 10% up on the curve. This procedure should be repeated for each channel, in the order specified by the set manufacturer.
- c. Obtain the over-all response curve, and follow procedure 1, using the TV station signal to mark the curve.

* * * VII. SPECIAL FUNCTIONS AND PROCEDURES * * *

1. INTERNAL MARKER OSCILLATOR

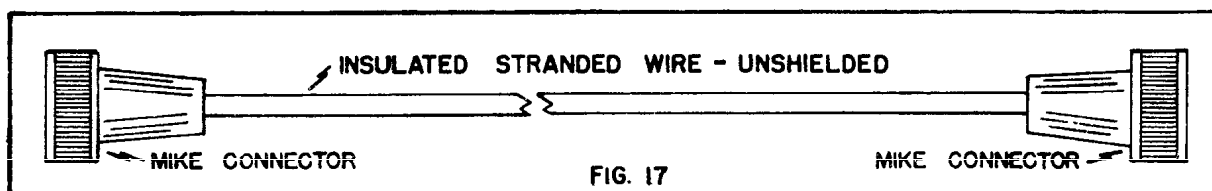
It will be noted that two crystals are provided with each Series E-400 Sweep Generator. One crystal already previously noted is the 4.5 Marker Crystal. The purpose of this crystal is primarily for use as a marker in the alignment of intercarrier sound stages.

The other crystal standardly provided with the Series E-400 is a 2000 KC. crystal, for use ONLY in checking calibration of any external Variable Marker Generator which may be used (such as PRECISION Series E-200 or E-200C).

A visual method by which the calibration of an External Marker Generator is accomplished is detailed as follows: (See Fig. 24).

A. A.M. Signal Generator Calibration in the vicinity of TV Video I.F. frequencies.

1. The Vertical terminals of the oscillograph are connected across the second detector load resistor of the picture (Video) I.F. system of any television receiver.
2. The output of Series E-400 is connected to the first picture I.F. grid (nearest the converter).
3. A picture of the I.F. response curve will then be obtained on the oscillograph.
4. The 2000 KC. crystal is then inserted into the multiple crystal socket of the E-400.
5. The OUTPUT of the crystal oscillator is also connected to the first picture I.F. grid, using the "Marker Cable" and the Cable Adapter. (Connects between the "CRYSTAL MARK. OUTPUT" connector on the E-400 panel and the first Picture I.F. grid).
6. Increased transfer of energy from the E-200C to the E-400 can be obtained by use of an unshielded interconnecting wire. As shown in Fig. 17, the operator can make use of two standard microphone connectors and a suitable length of insulated stranded wire for the purpose.



It is not recommended that the unshielded interconnector be used in general alignment procedures, because the open wire will radiate excessive amounts of R.F., particularly at higher frequencies.

7. As the "Marker Amplitude" control of the E-400 is rotated, a series of "pips" are produced by harmonics of the 2000 KC. crystal and are therefore spaced exactly 2000 KC. (2 MC) apart on the curve.
8. Next, the output of the Variable Marker Generator (such as PRECISION series E-200 or E-200C) is also connected to the first picture I.F. grid. As the main tuning dial of the Variable Marker Generator is rotated to approximately the video I.F. frequency, a traveling "pip" caused by the Variable Marker Generator, will also appear on the I.F. response curve.

NOTE: The above method of connections (three R.F. outputs simultaneously connected in the Picture I.F. grid) may result in distortion of the visual response curve. This condition is of no importance in this particular test.

9. The tuning dial of the Variable Marker Generator is then adjusted until its "pip" is superimposed directly over one of the "pips" caused by the 2 MC. internal crystal oscillator.

NOTE: Exact superimposition of the two "pips" will be indicated on the I.F. response curve, by the presence of "wiggly" lines at either end of the overall response curve. (Audio frequency beat"). See Fig. 24.

10. The exact reading on the Variable Marker Generator should then be noted. The reading on the FREQUENCY SCALE of the Variable Marker Generator should be fairly close to an even multiple of 2 MC. (Such as 22 MC., 24 MC., etc.), if the Variable Marker Generator is in well calibrated condition. If the A.M. signal generator has a VERNIER scale (such as on PRECISION Series E-200 or E-200C), this numerical DIAL SETTING should be jotted down, giving the operator an exact dial setting for 22 MC., 24 MC., etc.
11. Next, rotate the main tuning dial of the Variable Marker Generator until its traveling "pip" coincides with the next 2 MC. "pip" on the response curve.
12. Again, the operator must check the calibration on his Variable Marker Generator and note the reading obtained.
13. This procedure is repeated until all the 2 MC. "pips" on the response curve have been checked. The operator then has acquired a set of exact calibrations over the frequency range represented by the response width of the I.F. pattern. All intervening points on the Variable Marker Generator may then be calibrated by simple interpolation. After such has been done, the operator may use his Variable Marker Generator as an accurate source of markers or "pips" for a reasonable length of time.

NOTE: Another fully satisfactory method for crystal checking the calibration of the External Marker Generator (E-200C) is detailed on Page 27.

B. CRYSTAL NOTES

The internal Crystal Marker oscillator of the E-400 is designed to oscillate when used with crystals whose fundamental frequencies may range from two megacycles to approximately 15 megacycles. In order to obtain "pips" or "markers" at frequencies higher than approximately 15 megacycles, it becomes obvious that harmonic output of the crystal oscillator must be used. Specially designed harmonic operating crystals are made for this purpose.

For example: The 4.5 MC crystal supplied with the E-400 is used to obtain a "pip" at its 4.5 MC. fundamental or if desired at the 5th harmonic, i.e., 22.5 MC. Should the operator desire to use the internal marker oscillator for obtaining a "pip" at 11 MC., the fundamental frequency of the crystal to be obtained would be one half of 11, or 5.50 MC. The oscillator in this case, will be operating on a 2nd harmonic.

In order to obtain "pips" at relatively high frequencies such as 30 MC., it is necessary to obtain crystals which will operate in the oscillator at a 3rd harmonic. For example: In order to obtain a 30 MC. "pip" a crystal whose fundamental frequency is one-third of 30 MC. (10 MC.) must be used. Should the operator attempt to obtain crystals whose fundamental frequencies are above approximately 10 MC. he will find such crystals difficult and expensive to procure. Still higher desired frequencies are obtainable by use of crystals operating on 4th or higher harmonics.

IMPORTANT NOTE: Only crystals in type "FT-243" crystal holder should be inserted into the sockets of the E-400. Additional crystals of various frequencies may be obtained from the usual source of radio and electronic components. Precision Apparatus Company, Inc., does not stock crystals at frequencies other than the 4.5 MC. and 2000 KC. frequencies furnished as standard accessories to the E-400. If your distributor cannot service your special crystal requirements, it is suggested that many custom Crystal sources will be found listed in Amateur Radio Journals, such as "QST" and "CQ".

2. AMPLITUDE MODULATION FACILITIES

With the "SWEEP RANGE" switch set to "DEV. OFF" the frequency modulated oscillator within the Series E-400 becomes a straight R.F. oscillator. Under this condition, all frequencies indicated on the main tuning dial obtainable from the E-400 are unmodulated R.F. signals.

Should a source of audio frequency voltage then be applied to the "Audio Mod." pin jacks on the E-400 panel, the output on the E-400 on all bands becomes an amplitude modulated R.F. signal. Under these conditions, the Series E-400 is useable as a UHF A.M. Signal Generator.

With the use of an external source of audio frequency, in conjunction with the frequency modulation facilities of the Series E-400, the E-400 output becomes a combination of frequency plus amplitude modulated signal. Such type of signal is particularly useful in certain applications such as wherein anti-A.M. action of the limiter stage of an F.M. receiver is to be checked simultaneously with the passage of a frequency modulated signal. Such type of test would not necessarily be included in the usual routine service technique but becomes useful in many extended laboratory type tests.

*** * * VIII. SERVICE NOTES * * ***

The R.F. oscillators and the reactance modulator units of the Series E-400 are quite critical in adjustment and calibration. Therefore, under no circumstances should the operator attempt to recalibrate these oscillators without first having familiarized himself with CHAPTER X. "CALIBRATION NOTES AND PROCEDURES" (Page 27.)

The nature of the reactance modulating unit is such that continuous useage may produce slightly increased mechanical deviation at full setting of the Sweep Width Control. This slight over-drive of the unit evidences itself by a noteable "buzzing" sound from within the instrument when the Sweep Width Control is set to maximum in conjunction with the "15 MC." setting of the Sweep Width Switch.

If such a condition should occur reduction of the excitation of the reactance modulating unit may be considered desirable. In such case, the metal can of the instrument may be removed by loosening the 12 panel mounting screws and the setting of the applicable calibrating control may be reduced by a simple screw-driver adjustment. The location of the proper control is indicated in Fig. 18.

R.F. oscillator and associated tube replacements may result in slight frequency shift due to the varying internal capacitance of the new tubes. These frequency shifts will, in most cases, probably be very slight and should not seriously affect the useful calibration of the instrument.

IN ALL CASES WHERE FAULTY OPERATION OF THE INSTRUMENT IS SUSPECTED, THE SERVICE DEPARTMENT OF PRECISION APPARATUS COMPANY, INC., SHOULD FIRST BE CONSULTED. SHOULD THE SERVICE DEPARTMENT RECOMMEND RETURN OF THE INSTRUMENT TO THE FACTORY, THE COMPLETE INSTRUMENT WITH ALL ITS CABLES SHOULD BE CAREFULLY PACKED IN A STRONG CORRUGATED SHIPPING CARTON AND ADDRESSED TO:

Precision Apparatus Company, Inc.
92-27 Horace Harding Blvd.,
Elmhurst, L.I., N.Y.

ATT: Service Department

IMPORTANT NOTE: The original carton and fillers of the Series E-400 are admirably suited for this purpose.

IMPORTANT!!!!

If ever the Series E-400 is to be returned to the factory for repair and recalibration, a COMPLETE description of faulty operation as noted by the operator MUST accompany the instrument. The more details submitted to the Service Department of PRECISION, the more quickly and efficiently the instrument can be repaired and returned. It is very important that this description of faulty operation be described in unusually exact detail due to the fact that in many cases, faulty operation can be traced to difficulties in other items of test equipment and/or to improper analysis of results obtained.

YOUR SERIES E-400 SWEEP GENERATOR (LIKE MOST ALL UHF EQUIPMENT) IS A RELATIVELY CRITICAL AND DELICATE INSTRUMENT. DO NOT ATTEMPT ANY MAJOR REPAIRS OR ALIGNMENT BEFORE CONSULTING THE SERVICE DEPARTMENT OF PRECISION APPARATUS COMPANY, INC.

* * *
ACCESSORIES INCLUDED

Accompanying each Series E-400 is a bag containing the following standard accessories:

- *a. 1 ea. Marker Crystal Type X-4C.
Frequency 4.5 MC..
- *b. 1 ea. Calibrator-Marker Crystal
Type X-4C (Frequency 2 MC.)
- c. 1 ea. Terminated Coaxial Output Cable.
- d. 1 ea. Marker Injection Cable.
- e. 1 ea. Horizontal Sweep Connecting Cable.
- f. 1 ea. Grounding Braid.
- g. 1 ea. Cable Connector Adapter Unit.

*Series E-400 up to Serial # 6000 were supplied with one 10.7 Mc. crystal and one 2000Kc. crystal. The 4.5 Mc. crystal replaces the 10.7 Mc. crystal in Series E-400 above Serial # 6000. * * *

IX. SPECIAL NOTES

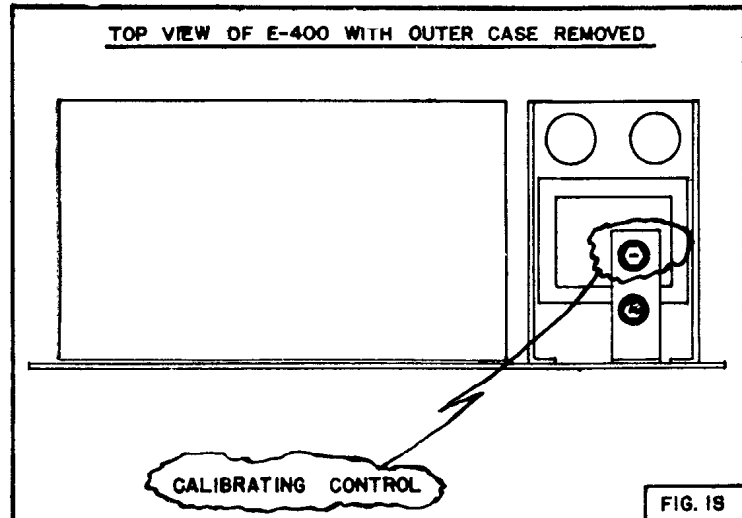
1. AN UNDERSTANDING OF SWEEP GENERATOR CALIBRATION ACCURACY.

In order to adequately cover the extended frequency spectrum required in F.M. and T.V. receiver servicing, Sweep Signal Generators incorporate a beat frequency system of R.F. generation as previously noted.

The dial calibrations on Bands "A", "B" and "D" result from sum or difference beats between the Variable Frequency-Modulated Oscillator and either one of the two fixed frequency oscillators. Bands "C" and "E" are produced by the output of the Variable Frequency-Modulated Oscillator alone and therefore do not involve beat frequency signals.

Each of the three oscillators (Variable Frequency Oscillator, 71 - 120 MC; Fixed High Frequency Oscillator, 75 MC; and Fixed Low Frequency Oscillator, 37.5 MC) are individually factory calibrated to an accuracy of $\pm 1\%$ or better. Bands "C" and "E" therefore, being produced by the Variable Frequency Oscillator alone, will directly produce signals accurate to $\pm 1\%$.

However, let us now consider Band "A" which results from the subtractive beating of the 75MC Fixed Frequency Oscillator with the 71 to 120 MC VFO. It can be seen that although each of the two oscillators involved are individually calibrated to $\pm 1\%$, the difference beat signal (calibrated on the dial as Band "A") may not fall within the $\pm 1\%$ of the dial indication. This is readily understood if we examine the following simple facts:



Assume the main tuning dial of the E-400 is set to 25 MC. This signal is produced by the Variable Frequency-Modulated Oscillator operating at 100 MC and beating against the fixed 75 MC oscillator. The difference between these two frequencies is 25 MC. and is calibrated as such on Band "A". If the VFO frequency at 100 MC happens to be just at the + 1% tolerance limit, this oscillator will produce a signal of 101 MC. If the 75 MC oscillator should be operating at the - 1% tolerance limit, this oscillator will produce a signal of 74.25 MC--- 101 MC minus 74.25 MC equals 26.75 MC, or a potential frequency error of + 7% at 25 MC. This + 7% error at 25 MC would be produced in spite of the fact that both oscillators contributing to the signal were individually within their $\pm 1\%$ frequency tolerance.

This condition becomes magnified when subtractive beats are used and appears as a progressively greater error on Band "A" as the dial is tuned to lower frequencies.

A similar condition, but to a lesser degree, can exist on Band "B", inasmuch as this band is also necessarily produced by subtractive beat. This time, it is the 71 - 120 MC VFO and the 37.5 MC Fixed Frequency Oscillator.

Band "C" produced directly by the VFO only, is not a beat band and will therefore maintain its accuracy of $\pm 1\%$ over its entire calibration.

Band "D" is produced by an additive beat of the 37.5 MC Fixed Oscillator with the VFO and can result in a much smaller potential error as compared even to the direct Band "C". For example:

The calibration on Band "D" at 120 MC is produced by the additive beat of $82.5 + 37.5 \text{ MC} = 120 \text{ MC}$. If the VFO be off calibration to the extent of + 1%, the frequency of this oscillator would be 83.32 MC. If the 37.5 MC oscillator was also off calibration to the extent of - 1%, the output of this oscillator would be 37.125 MC. Now $83.32 \text{ MC} + 37.125 \text{ MC} = 120.445 \text{ MC}$ or a frequency error of only .37%. It can therefore be seen that frequency errors on the additive "D" band can actually be less than the tolerance of the individual oscillators because of the additive process involved.

Band "E", "X" and "Y" are produced by the Variable Frequency Oscillator alone and will therefore be within $\pm 1\%$ over their complete calibration range.

* * * * *

After the calibration accuracy limits of the Series E-400 are fully established, it is important that the operator be fully familiar with the degree of dial calibration accuracy that is actually required in F.M. and T.V. servicing.

In the low frequency range, 2 - 45 MC (Band "A") the Sweep Generator is used almost exclusively for Sound and Video I.F. alignment. For these applications wherein injected Frequency marking "Pips" are an absolute necessity, the Dial calibration is used only as a guide to the approximate center frequency of the I.F. system, assisting the operator in bringing the full response curve into view on the oscillograph screen. Injected Marker "Pips" are then used to check frequency distribution and alignment.

At the higher channel frequencies wherein the Dial calibration is accurate to $\pm 1\%$ or better, as discussed above) the dial itself may be used quite satisfactorily for initial local oscillator channel frequency adjustment (TV), for receiver dial tracking (FM) and for other similar applications necessitating a relatively high degree of Generator Dial accuracy.

2. HOW TO USE THE O-160 NUMERICAL AND VERNIER SCALES

The O-160 scale along the upper circumference of the Series E-400 dial, WHEN EMPLOYED IN CONNECTION WITH THE TOP VERNIER PLATE, allows for direct numerical readings in tenths of one division providing 1500 readable points over the range of 0-150. The incorporation of this numerical reference scale, in addition to the direct frequency calibrated bands, allows for maximum accuracy in resetting to any desired frequency; in other words, it simplifies the matter of returning to EXACTLY the same dial spot when occasions demand it.

Another use of the numerical scale and vernier immediately suggests itself, wherein the occasion arises to spot various odd frequencies as may be employed in government, commercial, aeronautical, police, amateur or experimental services. In such cases, the Series E-400 is tuned to zero-beat against the exact frequency and the dial setting taken directly from the numerical scale and vernier. This more accurate reading can then be duplicated at any time, as well as rechecked with the greatest of ease.

When using the O-160 scale, the ZERO LINE of the vernier plate becomes the reference indicator INSTEAD OF THE RED HAIR-LINE OF THE LUCITE POINTER.

It will be noted that the 10 divisions on the O-10 vernier plate are ALWAYS to the right of the O-150 dial reading. These 10 vernier divisions are equal to 9 divisions on the O-160 scale, which factor provides the vernier action, that is, allows for reading the numerical scale in tenths of one division. For example:

Let us assume that for some specific case, the dial number under the vernier ZERO reference mark is somewhere between 28 and 29. Just what that EXACT decimal may be is difficult to ESTIMATE.

The vernier plate simplifies this problem. Merely look along the vernier scale and locate that ONE division of the 0-10 scale which most completely coincides (runs into) any one of the dial divisions directly below. If the seventh line of the 10 division vernier plate is THE one, then the decimal is .7 and the full reading is then 28 plus 7/10 or 28.7 ONE and only ONE vernier division can possibly fully coincide at a time with a dial division except for the two extremes ZERO and 10. When both the zero and 10 coincide, it indicates that the dial reading under the zero mark is complete, that is a WHOLE number, such as 29.0. Therefore, according to the theory of the vernier, a number can be read (when both zero and 10 are coincident) as either 29.0 or 28 plus 10/10, which are mathematically identical.

To reverse the procedure, that is, to set the dial according to a given numeral (let us assume 56.4 is desired), merely first set the dial so that the nearest whole number (56.0 falls under the ZERO of the VERNIER PLATE. Then watch the 4th division of the vernier plate and slowly rotate the dial TOWARDS the 57 mark, but STOPPING as soon as the .4 line on the vernier plate coincides with one of the dial divisions below it. This will naturally occur before the dial ever reaches the 57 mark.

* * * X. CALIBRATION NOTES AND PROCEDURES * * *

If, after a long period of usage, your Series E-400 generator appears to have shifted slightly in dial calibration (as a result of component stabilization) the following simple procedures will permit an accurate over-all calibration.

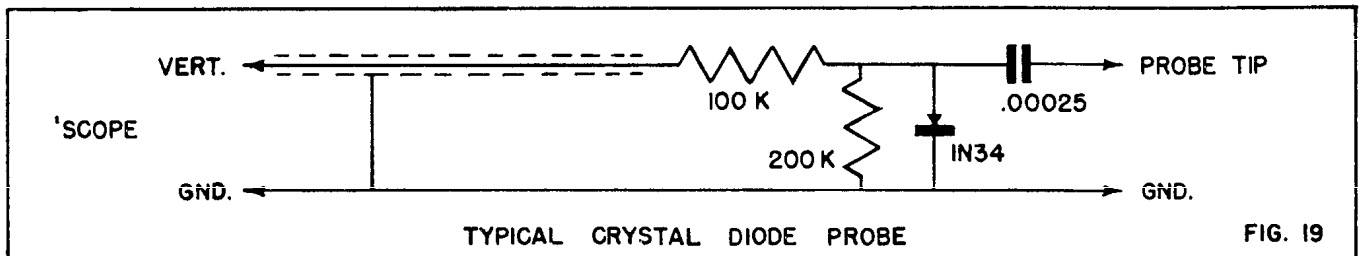
Should the calibration check indicate the need for realignment of the E-400, the operator may elect to re-trim the E-400 himself (in those cases wherein it is inconvenient or impossible to return the instrument for a factory realignment).

The calibration procedure first utilizes the crystal oscillator of the E-400 to check the dial calibration of the E-200C AM generator (or whatever AM generator the service shop utilizes) to crystal accuracy at 2 MC points along its dial. This first step which prepares the E-200C for use in calibration of the E-400 also provides the operator with a series of calibrations of crystal accuracy on his E-200C, which can then be used to great advantage when applying the E-200C as an accurate Marker Generator!

After this first step is completed, the E-200C itself is then used as an accurately calibrated standard against which the E-400 calibration is checked.

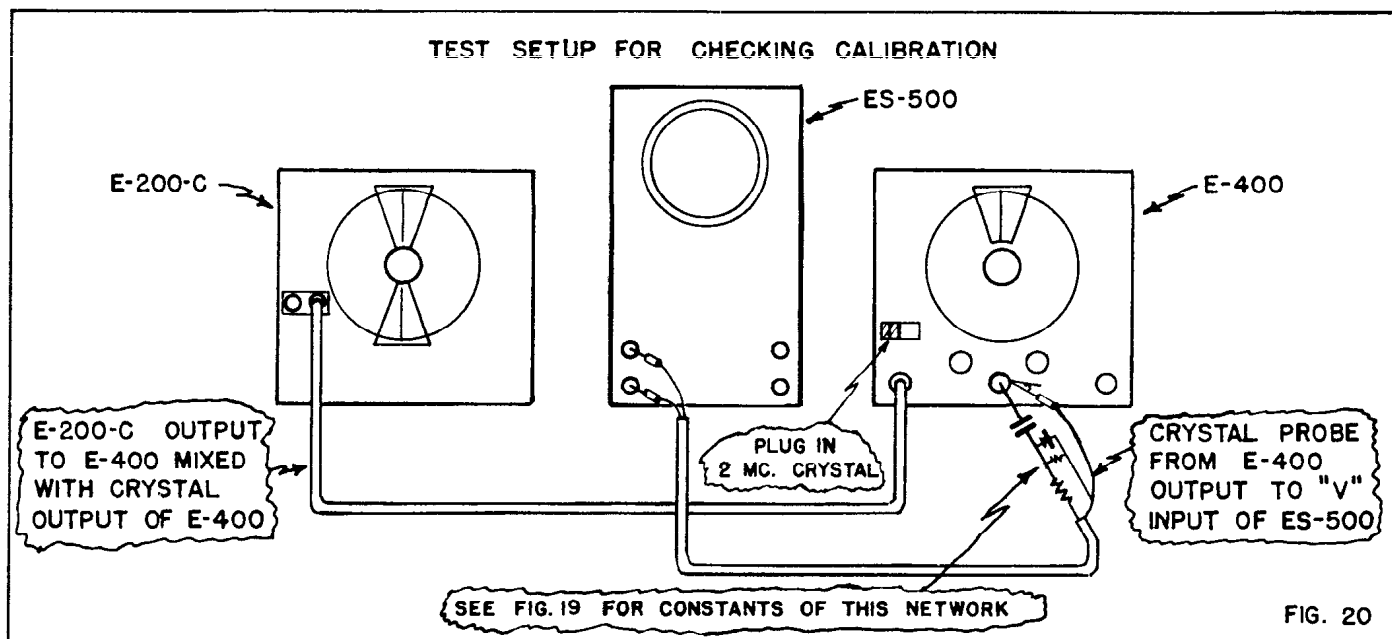
EQUIPMENT REQUIRED

- 1) A stable AM Signal Generator such as PRECISION Series E-200C.
- 2) Oscilloscope (preferably a high-gain scope such as Precision Series ES-500.
- 3) Crystal diode probe (Fig. 19).



Step 1. CRYSTAL CALIBRATION OF SERIES E-200C (or equivalent stable AM Generator).

- a) Connect the E-400, E-200C, ES-500 and crystal probe as indicated in Fig. 20.
- b) Set E-400 controls as follows: Set RF Level control to 10; Set Output control to 10; Switch in the 2 MC crystal; set Crystal Marker switch to ON; set Crystal Marker amplitude control to maximum; Set Band Selector switch to "Xtal Only"; set Sweep Range switch to "Deviation OFF." These control settings will put the 2 MC crystal oscillator in operation, and deliver maximum output voltage from the E-400 to the crystal probe.
- c) Set E-200C controls as follows: Set RF control #1 to 10; set RF control #2 to 10; set Band Selector switch to F; switch in Unmodulated RF. These control settings put Band F into operation and deliver maximum output voltage from the E-200C to the E-400 crystal oscillator.
- d) Set ES-500 controls as follows: Set Vertical sensitivity to X100; set Vertical Gain to 10; set Sweep Selector to Line position. These control settings provide maximum scope sensitivity and relatively slow sweep rate.
- e) Rotate the E-200C dial, and observe that a strong beat pattern is obtained on the scope at each 2 MC interval. The calibration points are the "zero beat" points at which the voltage



of the mixed output rises to a maximum, and at the same time the minimum number of cycles is seen on the scope screen. By very careful adjustment of the E-200C dial, the operator will find it possible to slow the beat down to zero, at which point an ellipse appears. Because this particular zero-beat adjustment is extremely critical, it will be observed that the pattern will tend to "breathe", or to drift slowly back and forth a few cycles per second. The operator will also observe that minor zero-beat points can be located between the major zero-beat points. These minor beats occur because harmonics of the E-200C will beat with harmonics of the crystal oscillator. The more important minor beats will be found at 1 MC. intervals on the "F" band. The beats will be stronger at the low-frequency end of the band, and weakest at the high-frequency end of the band, because the operator is making use of progressively higher harmonics. It is not likely that the E-200 will ever go out of calibration sufficiently to require correction. However, if due to rough handling or other unusual conditions, the dial should be slightly out of calibration, the operator should note down the exact 2 MC. points from the indication on the vernier logging scale. The E-200C will then be calibrated to crystal accuracy.

- f. Next, set the E-400 controls as follows: Set Crystal marker switch to OFF; set Band Selector Switch to "C" (Y). This is the basic band (swept oscillator) of the E-400, and covers a frequency range from 71 to 120 MC.
- g. Set the E-200C for 22 MC. output. Now, as the tuning dial of the E-400 is rotated, zero-beat indications will be noted on the scope at 88 MC., and 110 MC. (Of course, if the E-200C is set at some other frequency, such as 24 MC., beats will then be found at 72, and 96 MC.

NOTE: The calibration of an E-400 should first be checked only after a 30 minute warm-up period has elapsed.

Step 2. VARIABLE OSCILLATOR ADJUSTMENT.

- a) Allow the instrument to heat for approximately 30 minutes.
- b) Remove the instrument from its wrinkle-finished can.
- c) Set the A.M. Generator to exactly 22 MC. (The 5th harmonic of an A.M. Generator at 22 MC. will produce a beat pattern at exactly 110 MC).
- d) Note the setting of the E-400 dial at the beat point. If the reading is more than one-half division away from 110 MC., it may be "pulled in" by adjustment of the air trimmer located as indicated in Fig. 21 (T1).

NOTE: The adjustment required in any case, will be very slight. Use a non-metallic or low capacity alignment tool.

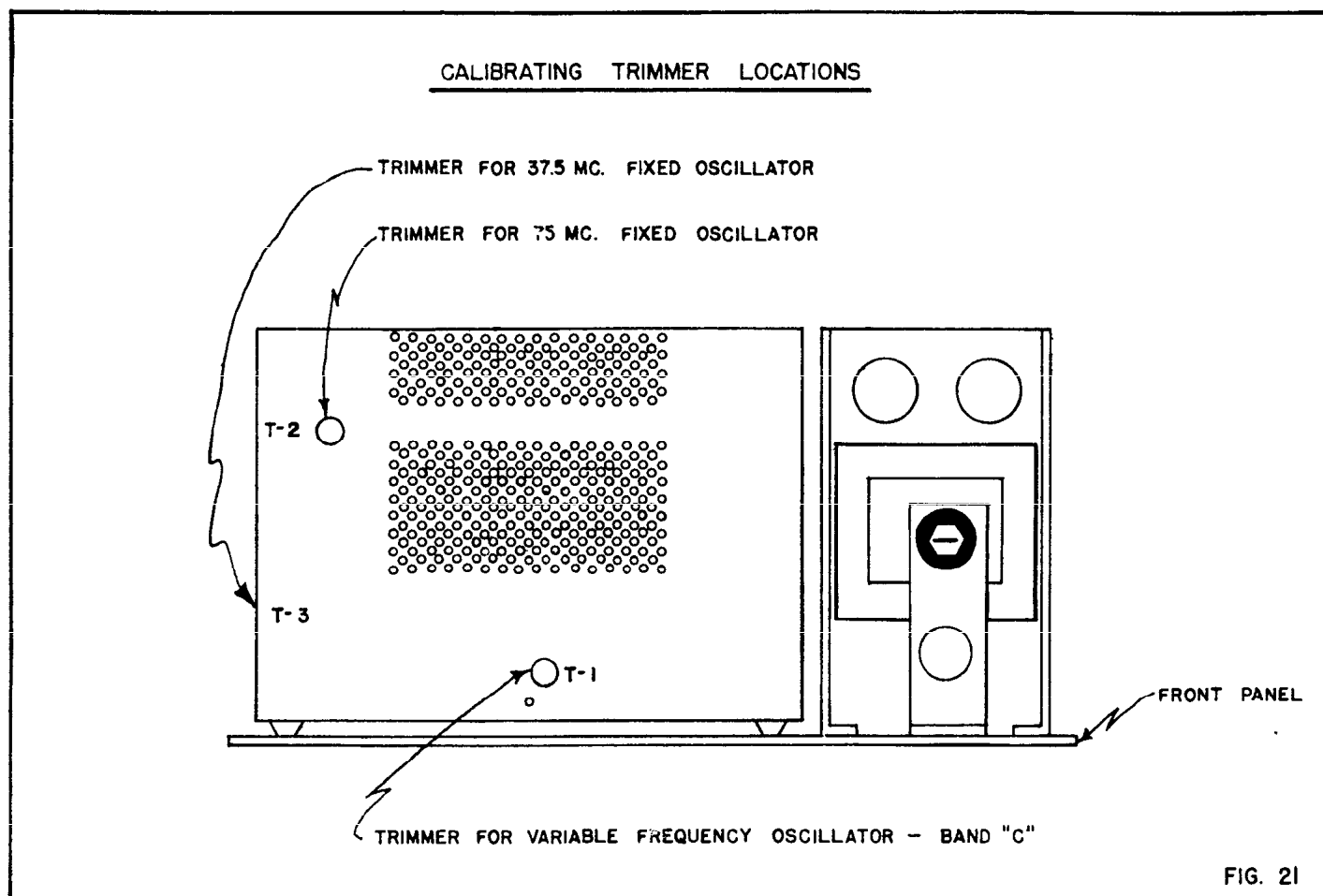
Step 3: CALIBRATION OF THE 75 MC. FIXED OSCILLATOR.

Band "A" results from the beating of Band "C" against the 75 MC. Fixed Oscillator. Inasmuch as Band "C" has already been accurately calibrated, the output of Band "A" at any one point will disclose the calibration of the 75 MC. oscillator. The procedure is detailed as follows:

- a) Set Band Selector switch of the E-400 to "A".
- b) Retain the E-200C setting at 22 MC. Set E-400 dial to 22 MC. or "A" band, and check for the zero-beat point on the E-400 dial. This zero-beat point should occur exactly a "22".
- c) Note the reading on Band "A". If the reading differs from 22 MC. by more than approximately one-half division, a very slight adjustment of the 75 MC trimmer (T2) noted on Fig. 21 should be made. Adjust this trimmer very carefully until zero-beat occurs with the E-400 dial set at 22 MC.

Step 4. ADJUSTMENT OF THE 37.5 MC. FIXED OSCILLATOR

Inasmuch as the 2nd harmonic of the 37.5 MC. oscillator is 75 MC., this oscillator may be adjusted exactly as described above, with the exception that the "Band Selector Switch" is rotated to "B" and the trimmer to be adjusted is located as illustrated in Fig. 21. E-400 dial is again read on the "A" band (22 MC) for this calibrating purpose. (Adjust trimmer T3)



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U.S.A.

BLOCK DIAGRAM OF SERIES E-400 SWEEP GENERATOR

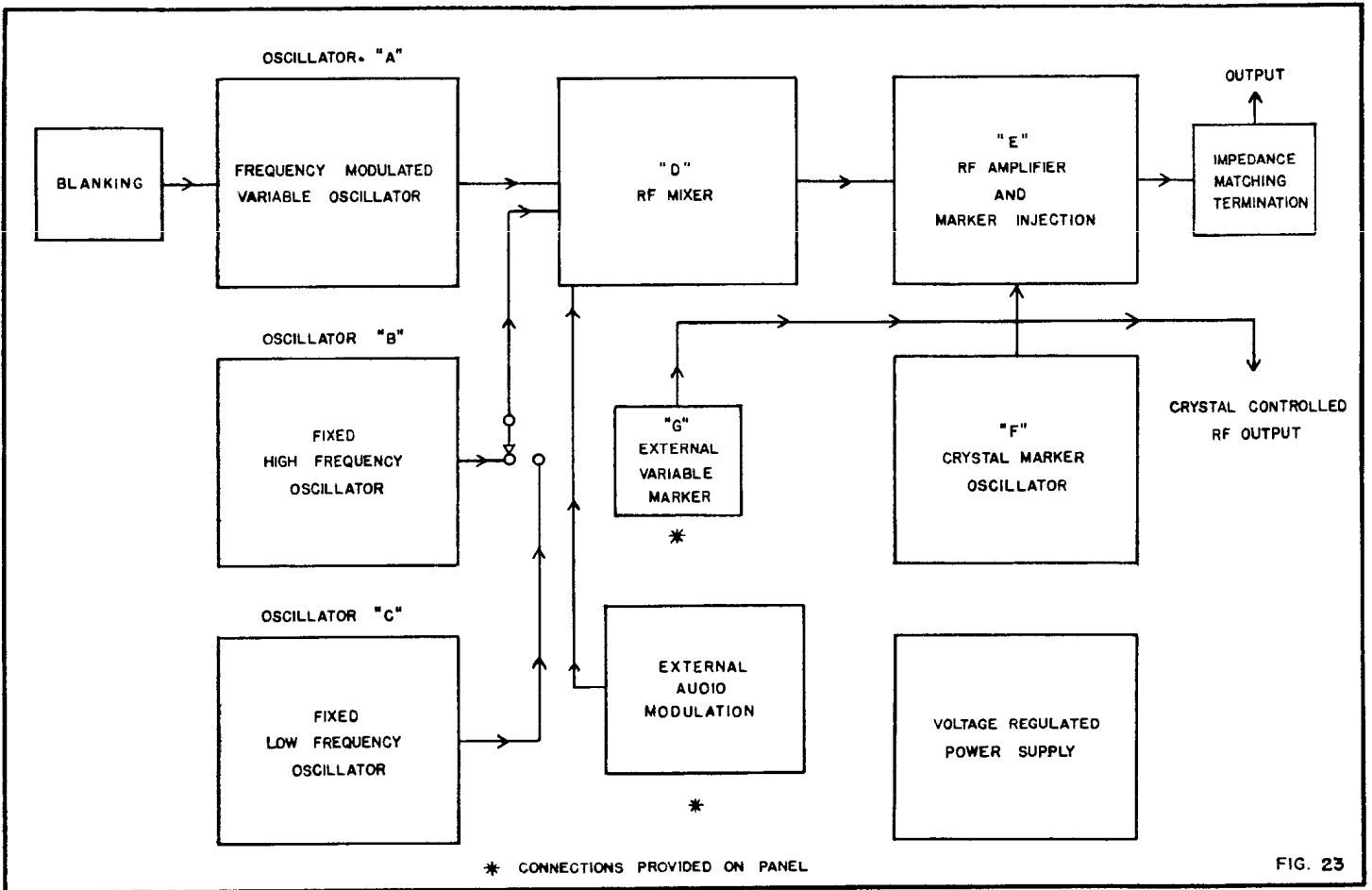


FIG. 23

A.M. GENERATOR CALIBRATION TECHNIQUE USING 2 MC. CRYSTAL

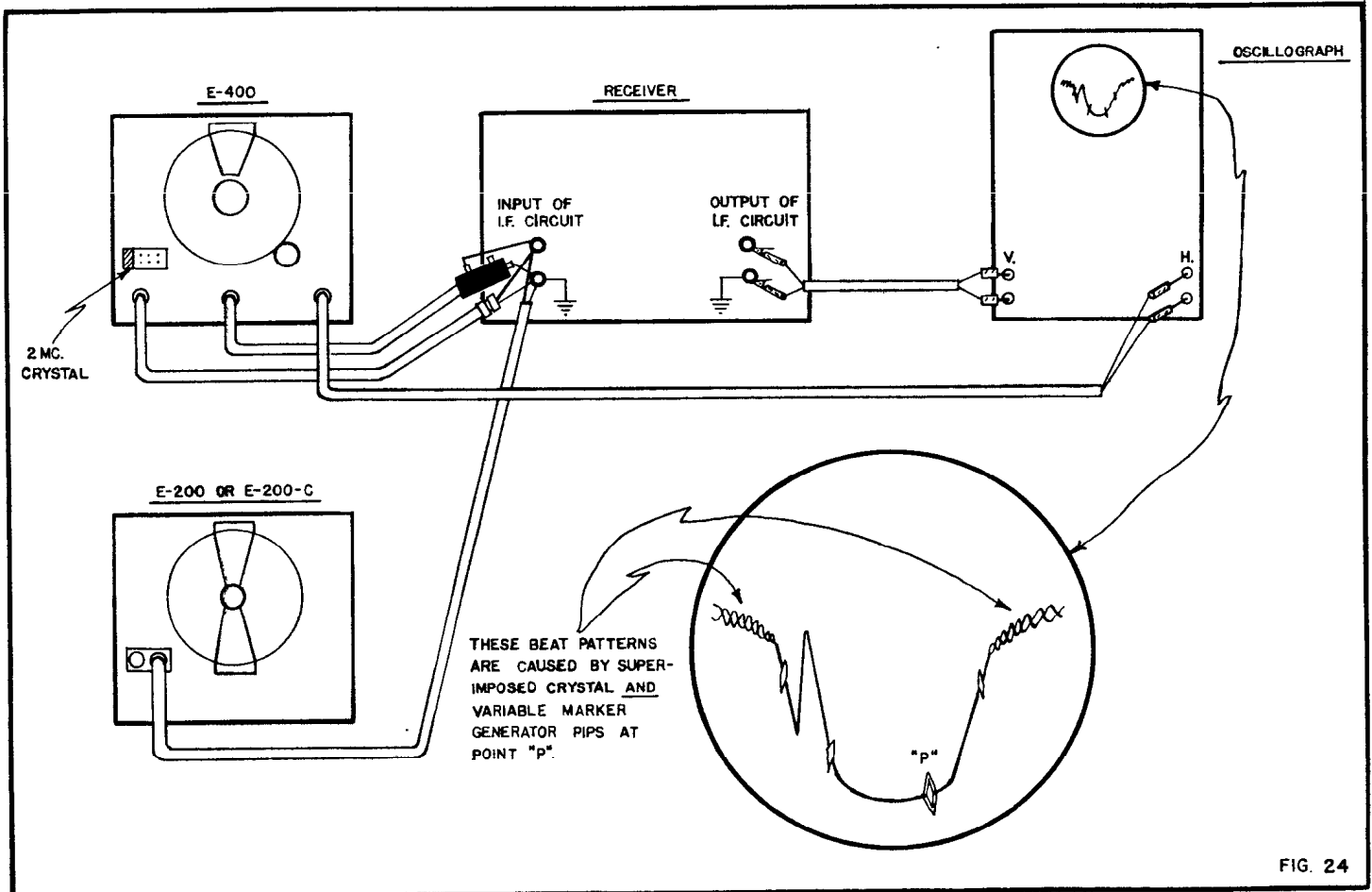


FIG. 24

ANALYSIS OF WAVE SHAPE OBTAINED ON OSCILLOGRAPH TUBE WHEN USING SWEEP GENERATOR

TYPICAL RESPONSE CURVE OF A TUNED CIRCUIT

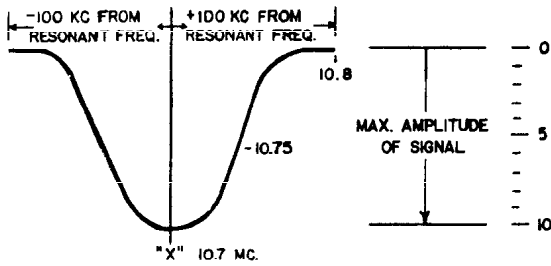
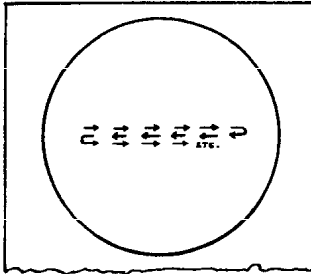


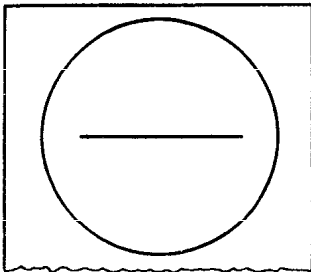
FIG.25-A

OSCILLOGRAPH ALONE - HORIZONTAL SWEEP MOVES BEAM BACK AND FORTH 60 TIMES PER SECOND

NO VERTICAL INPUT VOLTAGE



- ILLUSTRATIVE -
BEAM MOVEMENT

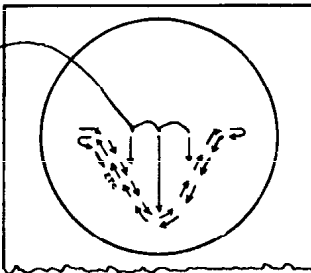


ACTUAL
VISUAL RESULT

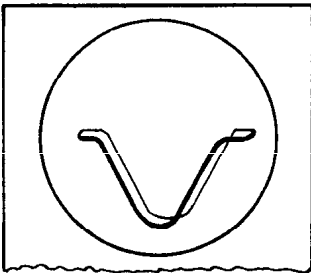
FIG.25-B

HORIZONTALLY SWEEPED BEAM BEING DEFLECTED IN ACCORDANCE WITH THE RESPONSE SHAPE OF THE TUNED CIRCUIT - DUE TO E-400 SWEEP ACTION

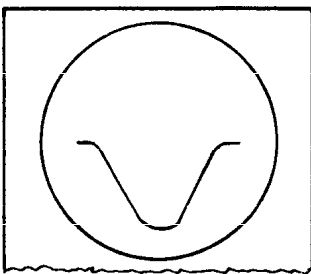
INSTANTANEOUS
VALUES OF TUNED
CIRCUIT RESPONSE
VOLTAGES - APPLIED
TO VERTICAL INPUT
OF OSCILLOGRAPH



- ILLUSTRATIVE -
BEAM IS STILL
SWEEPING BACK
AND FORTH 60
TIMES PER SECOND



ACTUAL
VISUAL RESULT
PHASE CONTROL
IMPROPERLY SET



ACTUAL
VISUAL RESULT
WHEN PHASED

FIG.25-C

ANALYSIS OF DOUBLE TRACE

AT THIS MAXIMUM
HORIZONTAL VOLT-
AGE POINT THE
BEAM REACHES
EXTREME LEFT
OF SCREEN.

60 CYCLE HOR.
SWEEP VOLTAGE
FROM E-400
APPLIED TO HOR.
SWEEP CONNECTIONS
OF OSCILLOGRAPH.

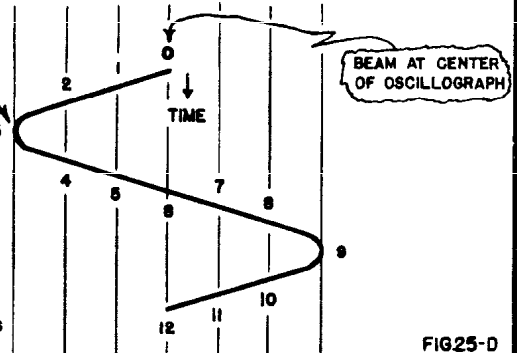


FIG.25-D

PATTERN APPEARING
ON OSCILLOGRAPH

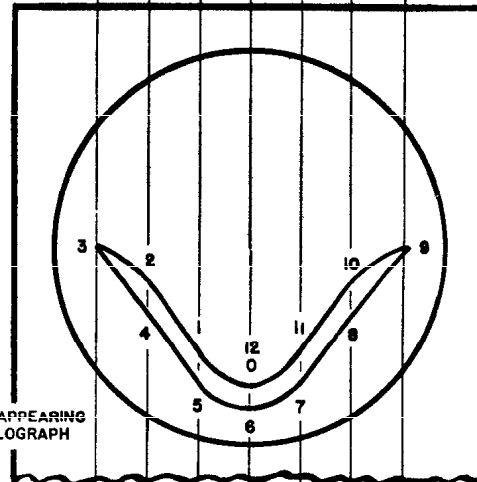


FIG.25-E

TYPICAL RESPONSE
CURVE

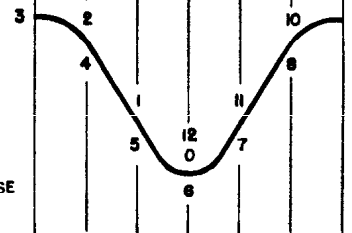


FIG.25-F

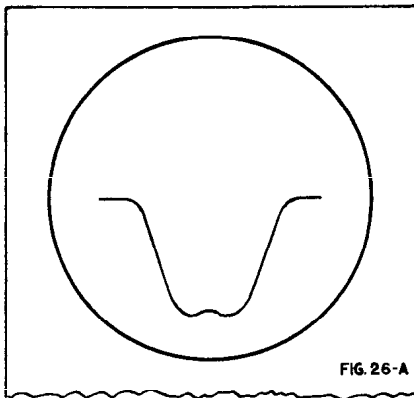
AT ONE INSTANT (FOR EXAMPLE), THE 60 CYCLE VOLTAGE FED TO THE HORIZONTAL AMPLIFIERS OF THE OSCILLOGRAPH IS ZERO (POINT 0, FIG. 25D ABOVE), CAUSING NO HORIZONTAL DEFLECTION OF THE BEAM.

AT THAT SAME INSTANT, HOWEVER, THE BEAM IS BEING VERTICALLY DEFLECTED TO A MAXIMUM (POINT 0, FIG. 25E ABOVE) BECAUSE OF THE RESPONSE OF THE TUNED CIRCUIT. (FIG. 25F).

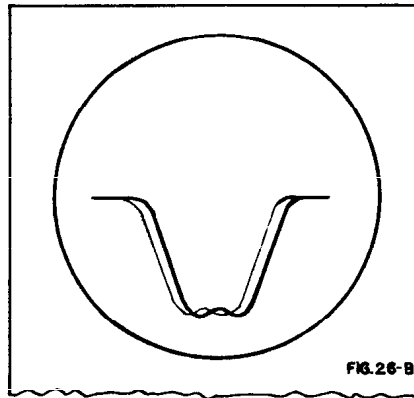
AT THE NEXT INSTANT, THE 60 CYCLE HORIZONTAL VOLTAGE HAS, FOR EXAMPLE, ADVANCED TO A SLIGHTLY POSITIVE VALUE (POINT 1, FIG. 25D), CAUSING A HORIZONTAL DEFLECTION OF THE BEAM TO THE LEFT SIDE OF THE CENTER OF THE SCREEN.

AT THAT SAME INSTANT, HOWEVER, THE BEAM IS BEING VERTICALLY DEFLECTED TO A SLIGHTLY LESS DEGREE THAN BEFORE, IN ACCORDANCE WITH THE RESPONSE OF THE TUNED CIRCUIT (POINT 1, FIG. 25E ABOVE).

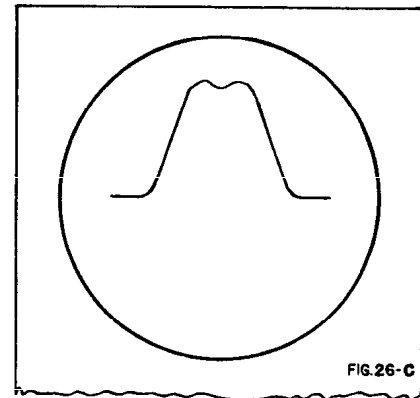
AN IDENTICAL ANALYSIS THROUGHOUT ONE COMPLETE CYCLE OF 60 CYCLE HORIZONTAL VOLTAGE (FIG. 25D), WILL REVEAL THE PATH OF THE COMPLETE DOUBLE TRACE PATTERN.



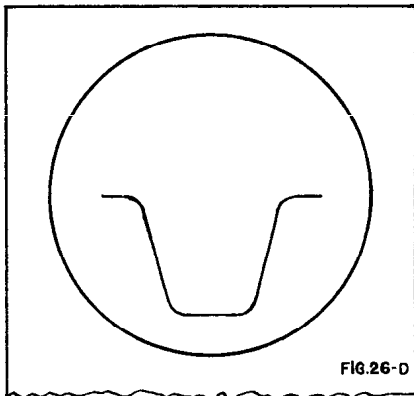
TYPICAL F-M I.F. RESPONSE CURVE



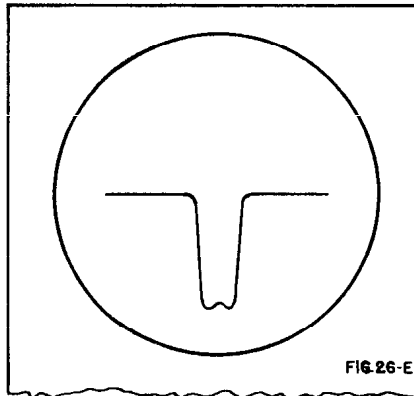
F-M I.F. RESPONSE CURVE - "PHASE CONTROL" IMPROPERLY SET.



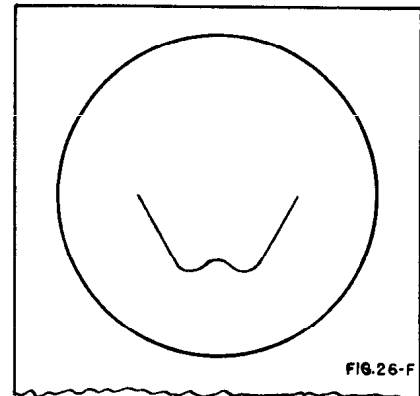
TYPICAL F-M I.F. RESPONSE CURVE - INVERTED - DEPENDENT UPON OSCILLOGRAPH AND RECEIVER.



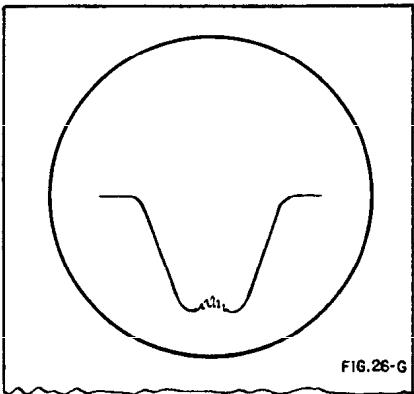
F-M I.F. RESPONSE CURVE - TOO MUCH SIGNAL INPUT.



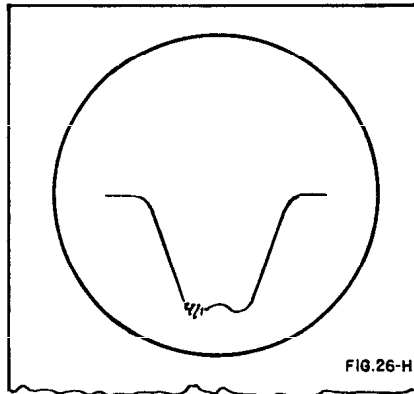
F-M I.F. RESPONSE CURVE - "SWEEP WIDTH" CONTROL TOO HIGH.



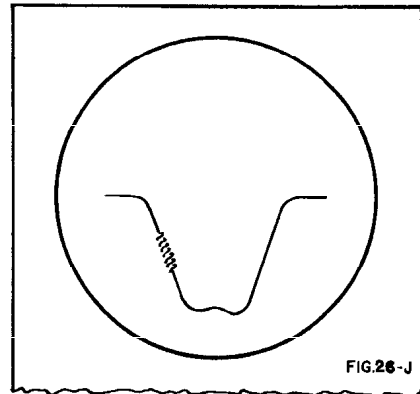
F-M I.F. RESPONSE CURVE - "SWEEP WIDTH" CONTROL TOO LOW.



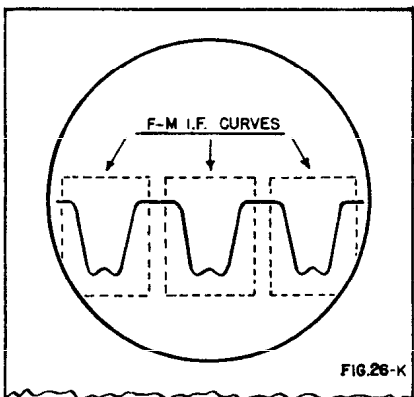
F-M I.F. RESPONSE CURVE - WITH MARKER AT MID-FREQUENCY POINT.



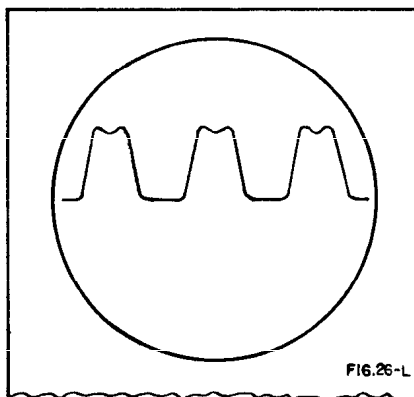
F-M I.F. RESPONSE CURVE - WITH MARKER AT SIDE FREQUENCY.



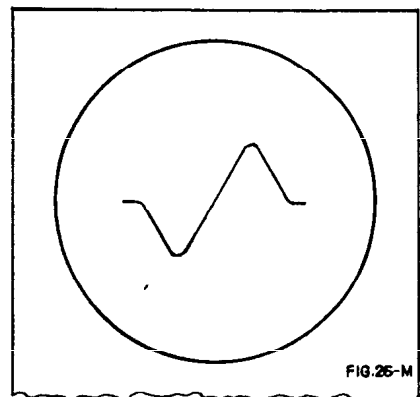
F-M I.F. RESPONSE CURVE - WITH MARKER ON SLOPE.



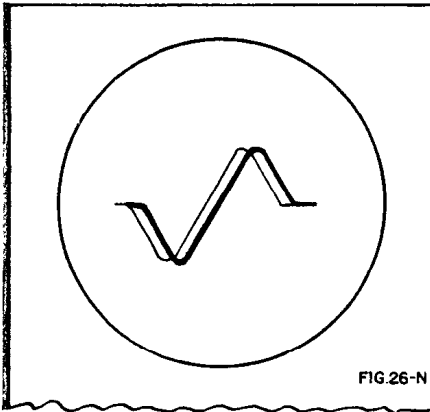
F-M I.F. MULTIPLE RESPONSE CURVES - USING INTERNAL HOR. SWEEP OF OSCILLOGRAPH.



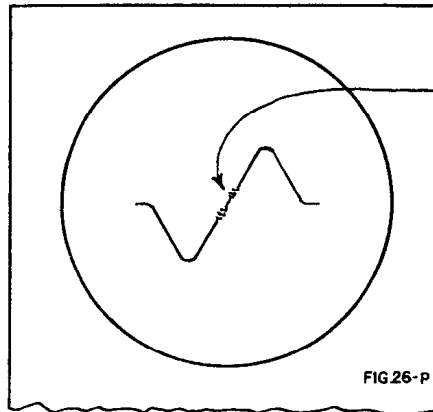
F-M I.F. MULTIPLE RESPONSE CURVES - INVERTED - DEPENDENT UPON OSCILLOGRAPH AND RECEIVER.



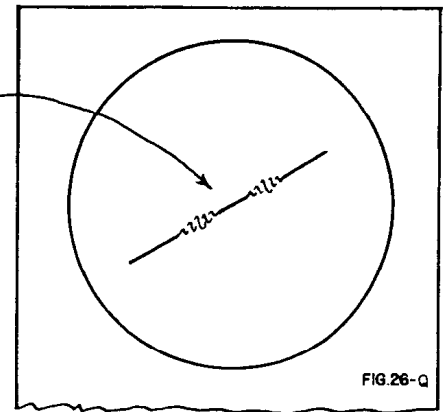
F-M DISCRIMINATOR I.F. RESPONSE CURVE



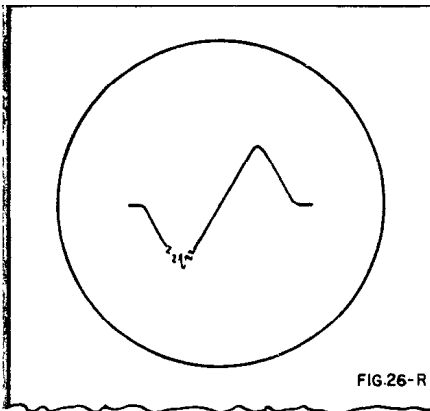
F-M DISCRIMINATOR I.F. RESPONSE CURVE-
"PHASE CONTROL" IMPROPERLY SET.



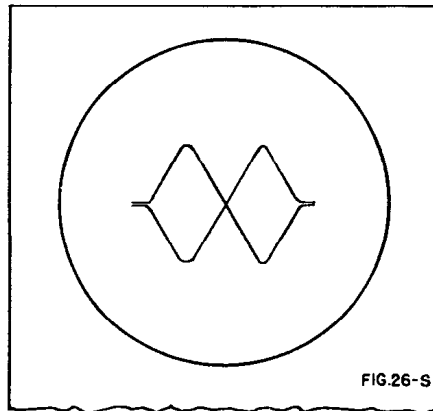
F-M DISCRIMINATOR I.F. RESPONSE CURVE- WITH
MARKER AT MID-FREQUENCY POINT.



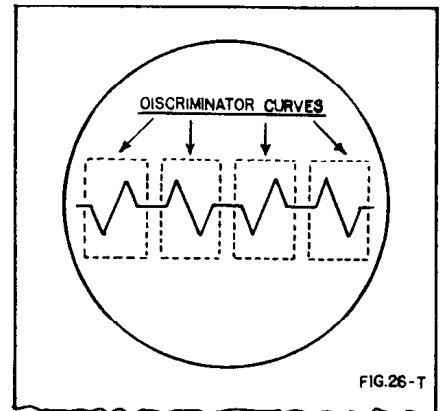
F-M DISCRIMINATOR I.F. RESPONSE CURVE- CENTER
PORTION OF CURVE EXPANDED.



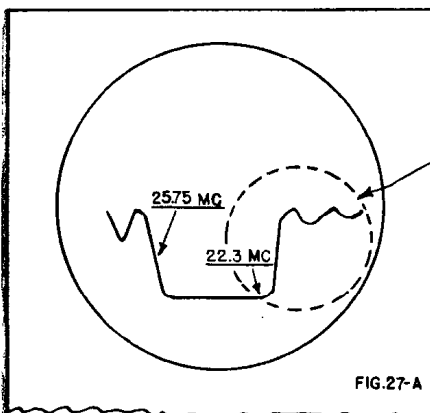
F-M DISCRIMINATOR I.F. RESPONSE CURVE- WITH
MARKER AT SIDE FREQUENCY.



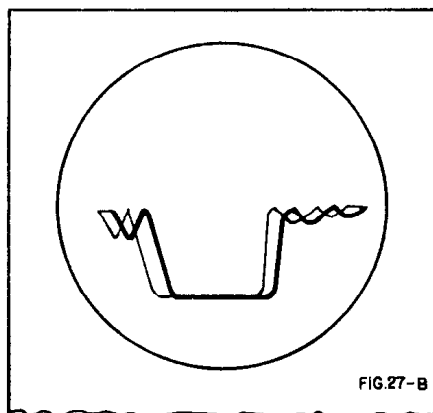
F-M DISCRIMINATOR I.F.-DOUBLE PATTERN-USING
INTERNAL HOR. SWEEP OF OSCILLOGRAPH.



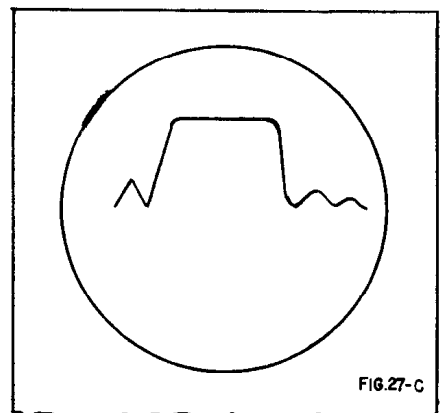
F-M DISCRIMINATOR I.F.-MULTIPLE RESPONSE CURVES-
USING INTERNAL HOR. SWEEP OF OSCILLOGRAPH.



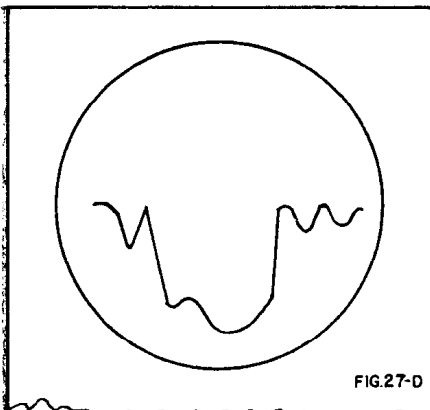
TYPICAL VIDEO I.F. RESPONSE CURVE



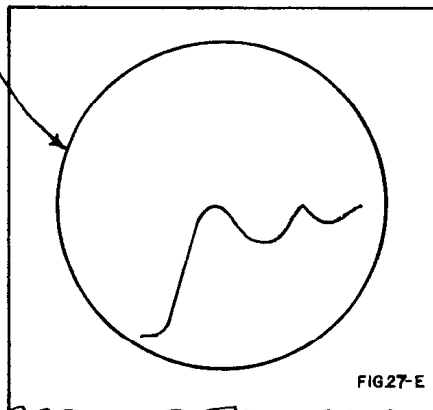
VIDEO I.F. RESPONSE CURVE-"PHASE CONTROL"
IMPROPERLY SET.



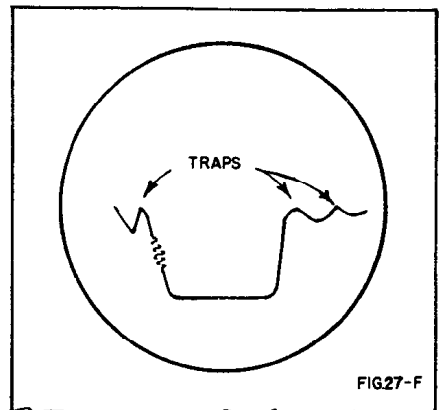
VIDEO I.F. RESPONSE CURVE - INVERTED -
DEPENDENT UPON OSCILLOGRAPH AND RECEIVER.



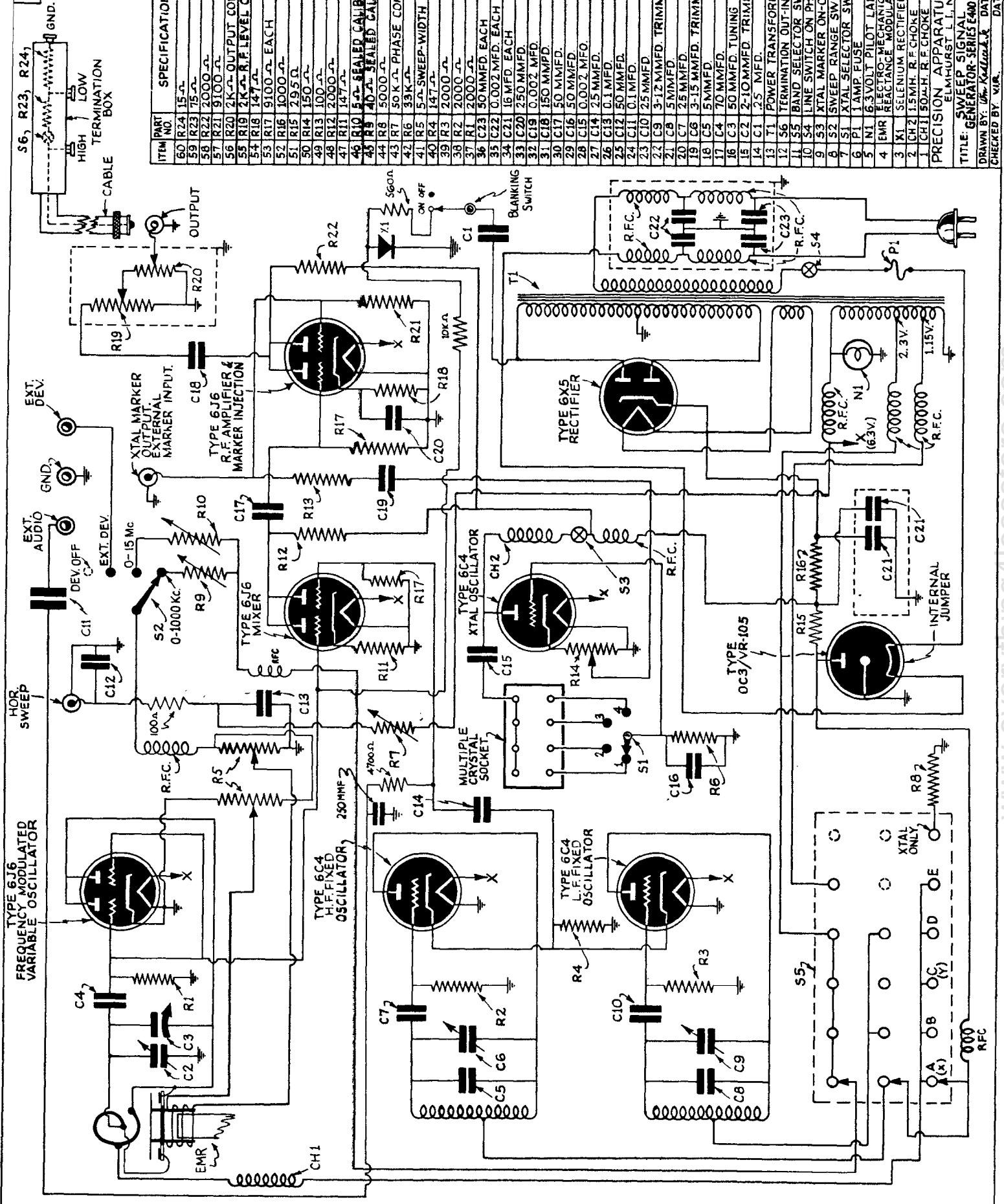
VIDEO I.F. RESPONSE CURVE - TOO MUCH SIGNAL
INPUT.



VIDEO I.F. RESPONSE CURVE-"SWEEP WIDTH"
CONTROL TOO LOW.

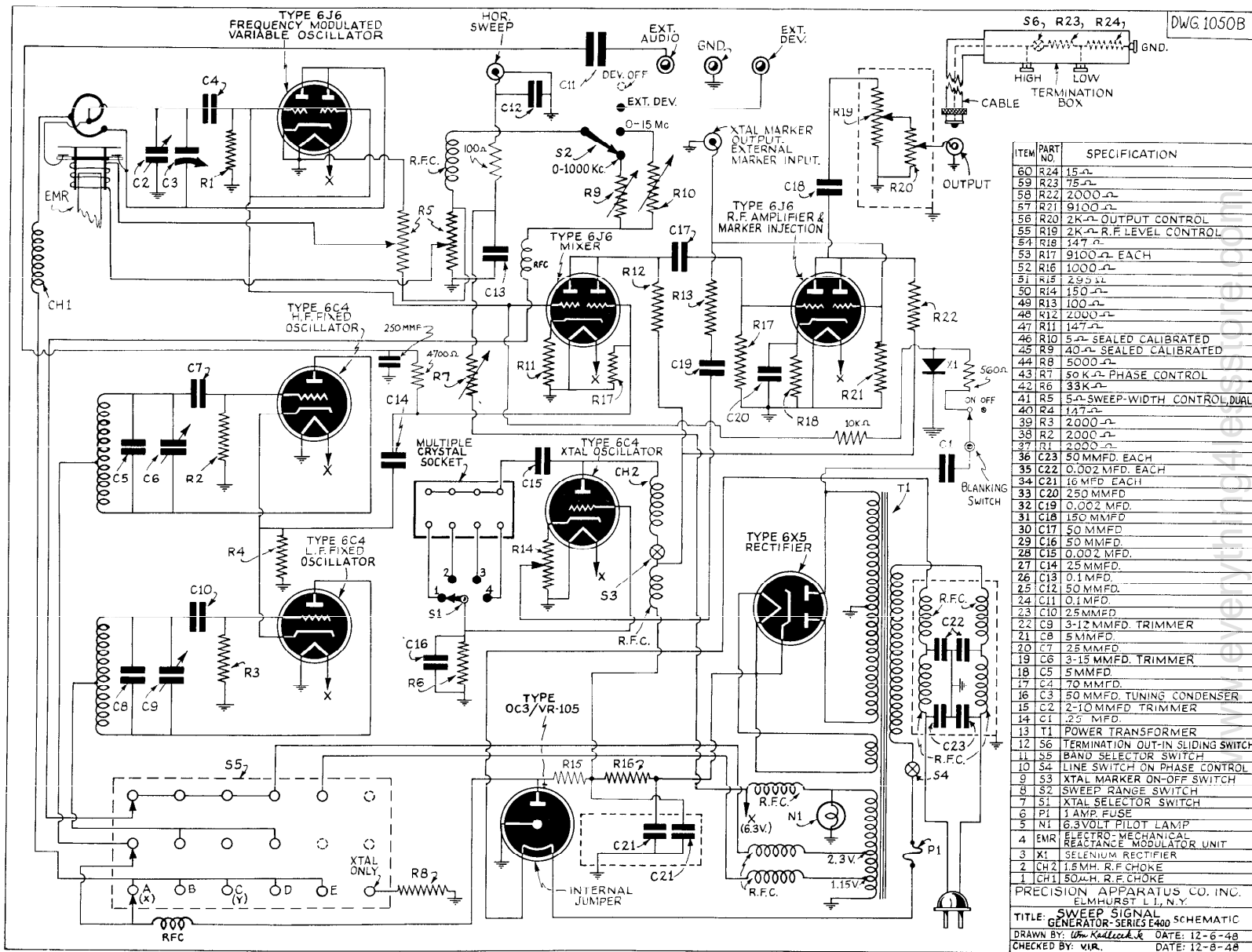


VIDEO I.F. RESPONSE CURVE- WITH MARKER ON
SLOPE.



ITEM NO.	PART NO.	SPECIFICATION
56	R24	15 Ω
57	R23	75 Ω
58	R22	1000 Ω
59	R21	9100 Ω
60	R20	2K Ω OUTPUT CONTROL
61	R19	2K Ω R.F. LEVEL CONTROL
62	R18	147 Ω
63	R17	9100 Ω EACH
64	R16	1000 Ω
65	R15	295 Ω
66	R14	150 Ω
67	R13	100 Ω
68	R12	2000 Ω
69	R11	147 Ω
70	R10	5 Ω SEALED CALIBRATED
71	R9	40 Ω SEALED CALIBRATED
72	R8	50 K Ω PHASE CONTROL
73	R7	33K Ω
74	R6	50 K Ω SWEET-WIDTH CONTROL
75	R5	5 Ω SWEET-WIDTH CONTROL
76	R4	147 Ω
77	R3	12000 Ω
78	R2	2000 Ω
79	R1	2000 Ω
80	C23	50MMFD. EACH
81	C22	0.002 MFD. EACH
82	C21	16 MFD. EACH
83	C20	250 MMFD.
84	C19	0.002 MFD.
85	C18	150 MMFD.
86	C17	50 MMFD.
87	C16	50 MMFD.
88	C15	0.002 MFD.
89	C14	25 MMFD.
90	C13	0.1 MFD.
91	C12	50 MMFD.
92	C11	0.1 MFD.
93	C10	25 MMFD.
94	C9	3-12 MMFD. TRIMMER
95	C8	5 MMFD.
96	C7	25 MMFD.
97	C6	3-15 MMFD. TRIMMER
98	C5	5 MMFD.
99	C4	70 MMFD.
100	C3	50 MMFD. TUNING CONDENSER
101	C2	2-10 MMFD. TRIMMER
102	C1	25 MFD.
103	T1	POWER TRANSFORMER
104	S6	TERMINATION OUT-IN SLIDING SWITCH
105	S5	BAND SELECTOR SWITCH
106	S4	LINE SWITCH ON-OFF SWITCH
107	S3	XTAL MARKER ON-OFF SWITCH
108	S2	SWEET RANGE SWITCH
109	S1	XTAL SELECTOR SWITCH
110	N1	1 AMP FUSE
111	P1	6.3VOLT PILOT LAMP
112	4	EMR ELECTRO-MECHANICAL REACTANCE MODULATOR UNIT
113	3	X1 SELENIUM RECTIFIER
114	2	CH2 1.5MH. R.F. CHOKES
115	1	CH1 150MH. R.F. CHOKES

PRECISION APPARATUS CO. INC.
ELMHURST, L. I., N. Y.
TITLE: SWEEP SIGNAL GENERATOR SERIES E-400 SCHEMATIC
DRAWN BY: Wm. K. L. DATE: 12-6-48
CHECKED BY: V.M. DATE: 12-8-48



TYPE 6J6
FREQUENCY MODULATED
VARIABLE OSCILLATOR

HOR.
SWEEP

EXT.
AUDIO

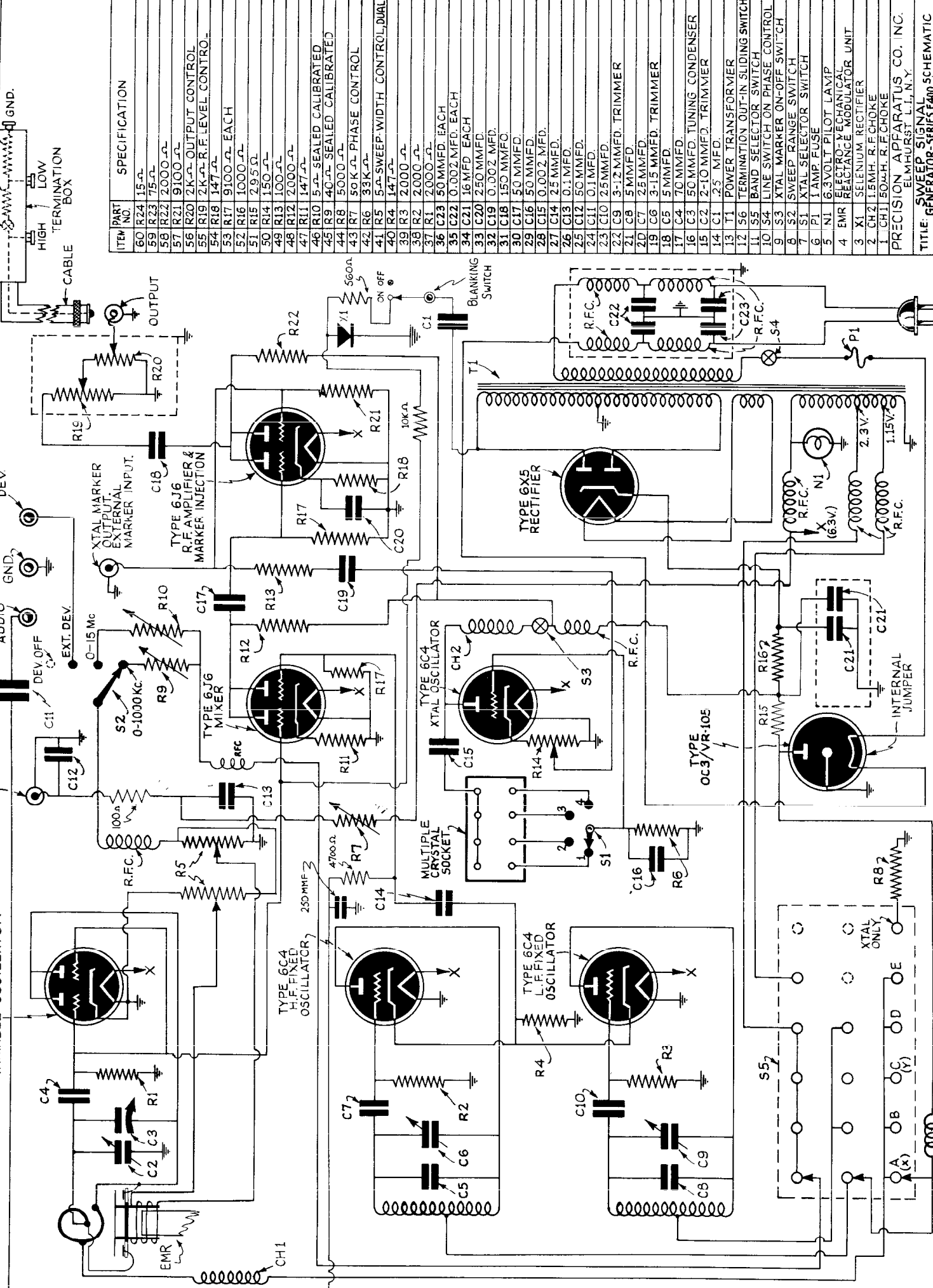
EXT. DEV.

EXT. DEV.

EXT. DEV.

EXT. DEV.

DWG 1050B



ITEM NO.	SPECIFICATION
60 R24	15 Ω
59 R23	75 Ω
58 R22	2000 Ω
57 R21	9100 Ω
56 R20	2K Ω OUTPUT CONTROL
55 R19	2K Ω R.F. LEVEL CONTROL
54 R18	147 Ω
53 R17	9100 Ω EACH
52 R16	1000 Ω
51 R15	295 Ω
50 R14	150 Ω
49 R13	100 Ω
48 R12	2000 Ω
47 R11	147 Ω
46 R10	5 Ω SEALED CALIBRATED
45 R9	40 Ω SEALED CALIBRATED
44 R8	5000 Ω
43 R7	50K Ω PHASE CONTROL
42 R6	33K Ω
41 R5	5A SWEEP WIDTH CONTROL
40 R4	147 Ω
39 R3	2000 Ω
38 R2	2000 Ω
37 R1	2000 Ω
36 C23	50 MMFD. EACH
35 C22	0.002 MFD. EACH
34 C21	16 MFD. EACH
33 C20	250 MMFD.
32 C19	0.002 MFD.
31 C18	150 MMFD.
30 C17	50 MMFD.
29 C16	50 MMFD.
28 C15	0.002 MFD.
27 C14	2.5 MMFD.
26 C13	0.1 MMFD.
25 C12	50 MMFD.
24 C11	0.1 MMFD.
23 C10	25 MMFD.
22 C9	3-12 MMFD. TRIMMER
21 C8	5 MMFD.
20 C7	25 MMFD.
19 C6	3-15 MMFD. TRIMMER
18 C5	5 MMFD.
17 C4	70 MMFD.
16 C3	50 MMFD. TUNING CONDENSER
15 C2	2-10 MMFD. TRIMMER
14 C1	25 MFD.
13 T1	POWER TRANSFORMER
12 S6	TERMINATION OUT-IN SLIDING SWITCH
11 S5	BAND SELECTOR SWITCH
10 S4	LINE SWITCH ON PHASE CONTROL
9 S3	XTAL MARKER ON-OFF SWITCH
8 S2	SWEEP RANGE SWITCH
7 S1	XTAL SELECTOR SWITCH
6 P1	1 AMP FUSE
5 N1	6.3VOLT PILOT LAMP
4 ENR	ELECTRO-MECHANICAL RELAY
3 X1	SELENIUM RECTIFIER
2 CH1	1.5MH. R.F. CHOKER
1 CH1	50H. R.F. CHOKER

TITLE: SWEEP SIGNAL
GENERATOR SERIES F400 SCHEMATIC
DRAWN BY: Wm. K. L. & J. E.
CHECKED BY: VIR.
DATE: 12-6-48
DATE: 12-8-48



RADIO • TELEVISION • ELECTRICAL • INDUSTRIAL • LABORATORY

*It is not "PRECISION" Test Equipment unless it is manufactured by
Precision Apparatus Company, Inc., of Elmhurst, L. I., N. Y.*